COMPACTION CHARACTERISTICS AND SHEAR PARAMETERS OF POND ASH

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
in
Civil Engineering

By
PADAM RAJ

Department of Civil Engineering

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Rourkela

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Under the Guidance of
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CERTIFICATE

This is to certify that the thesis entitled, "**Compaction Characteristics and Shear Parameters of Pond Ash**" submitted by **Mr. PADAM RAJ** in partial fulfillment of the requirements for the award of Bachelor of Technology Degree in Civil Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any Other University / Institute for the award of any Degree or Diploma.

Date:

Dr. S.P. Singh
Dept. of Civil Engineering
National Institute of Technology
Rourkela - 769008

ACKNOWLEDGEMENT

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I am indebted to the Department of Civil Engineering NIT Rourkela for providing us all facilities required for the experimental work.

An assemblage of this nature could never have been attempted without reference to and inspiration from the works of others whose details are mentioned in reference section. I acknowledge my indebtedness to all of them.

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Last but not the least; I am thankful to ALMIGHTY, who kept me for the necessary hard work during my thesis work

Date:

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SYNOPSIS

With the increase in the number of coal based thermal power plants in India, generation of coal ash has reached enormous proportions. India at present produces around 120 Million tonnes of Ash per annum. The power requirements of the country are rapidly increasing with increase in growth of the industrial sectors. India depends on Thermal power as its main source (around 80% of power produced is thermal power), as a result the quantity of Ash produced shall also increase. Indian coal on an average has 35 % Ash and this is one of the prime factors which shall lead to increased ash production and hence, Ash utilization problems for the country. Out of the total ash produced.

Fly ash contributes to a small percentage, majority being Pond ash and bottom ash. Ash disposal involves design and installation of ash ponds, which in addition to covering quite large area at each plant site, creates aesthetic as well as hygienic environmental impacts. This has warranted the scientific and industrial community to initiate research and development work for finding avenues for the innovative use and safe disposal of the pond ash so that instead of a waste product, the pond ash could be considered as a usable by-product. Though a lot of research has been carried out for the effective utilization of pond ash like its use in construction industry etc, little literature is available on pond ash utilization particularly its use as a foundation material. One way of disposing off pond ash would be its use as a structural fill material and use as embankment material in highways.

The present work aims at evaluating the response of pond ash to various compactive efforts. The compactive efforts have been varied as 595 kj/m^3 to 2674 kj/m^3 of sample and effect of compaction energy on MDD and OMC have been evaluated by conducting proctor compaction tests, the shear strength parameters of pond ash samples compacted to different dry densities and moisture contents.

Based on experimental findings the following conclusions are drawn.

- Increase in compaction energy facilitates closer packing of pond ash particles resulting in an increase in MDD
- MDD of compacted samples shows a linear relationship with the amount of compaction energy.

- The OMC of the samples is found to decrease with increase in compactive effort increased compaction energy forces the particles to come closer resulting in a reduced void space hence OMC is found to be 28%-39%.

- It is shown in results,With increase in compaction energy from 3639 to 35554 kg-cm, MDD of pond ash increases, but at the same time OMC decreases.

- shear strength tests on freshly compacted pond ash specimens at various water contents and different dry densities show that most of the shear strength is due to internal friction.

- Angle of friction doesn’t change much when we applied different compactive efforts

- With increase of compaction energy from 595 kj/m^3 to 2674 kj/m^3 per 1000 cc of compacted sample the MDD is found to change from 1.09 gm/cc and 1.27 gm/cc

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CHAPTER 1

INTRODUCTION

INTRODUCTION

Pond ash is the by-product of thermal power plants, which is considered as a waste material and its disposal is a major problem from an environmental point of view and also it requires a lot of disposal areas. Actually, there are three types of ash produced by thermal power plants, viz. (1) fly ash, (2) bottom ash, and (3) pond ash. Fly ash is collected by mechanical or electrostatic precipitators from the flue gases of power plant; whereas, bottom ash is collected from the bottom of the boilers. When these two types of ash, mixed together, are transported in the form of slurry and stored in the lagoons, the deposit is called pond ash.

The volume of pond ash produced by thermal power plants is very large compared to that of the other two ashes, viz. fly ash and bottom ash .The task to utilize the pond ash to the maximum possible extent is still a major problem throughout the world. To solve the problem, pond ash has potential applications in different areas like structural fills and highway embankment. Pond ash is a lightweight and self-draining material compared to natural soil. For successful application of pond ash as fill material in civil engineering construction, knowledge of compaction characteristics of the fill material is essential to achieve effective compaction in the field.

Pond Ash which can be used for soil improvements has gained tremendous impetus during the last two decades. Initial uses of pond ash, stabilized with lime, as a highway sub grade dates back to the late 1950s and early 1960s (Davidson & Handy 1960; Snyder and Nelson 1962). In1970s the variety of fly ash applications increased (Copp & Spencer 1970 Joshi etal 1975), and applications enveloping cement stabilized fly ash were introduced.

However, the present scenario of the utilization of pond ash in India is grim. About 8% of the produced fly ash is being used commercially .This shows that there exists a tremendous potential of utilization of pond ash in geotechnical constructions in order to preserve the valuable top soil.

Geotechnical constructions like embankments, retaining structures, etc require huge amount of earth materials. Rapid industrialization and non availability of conventional earth material have forced the engineers and scientist to utilize the waste product of industries which either degrade the environmental pose problems for their disposal. In this connection utilization of by- products like pond ash needs special attention. Pond ash is a byproduct of a coal fired thermal power plants and contains particles of fine sand to silt sizes. For the design of cement stabilized reinforced pond ash structures, a proper understanding of the interaction between reinforcement materials and stabilized fly ash is necessary.

Some research work has been carried out to find the suitability of compacted pond ash in geotechnical construction like embankments, retaining walls, structural fills ,etc However, these structures are to be protected from getting wet in order to preserve the inherent strength of the compacted pond ash, which is difficult task in field situations.

The present samples are obtained from ash ponds of DITE C, CPP-2 NSPCL, Rourkela.

CHAPTER 2

LITERATURE REVIEW

LITERATURE REVIEW

2.1 INTRODUCTION

Coal ash is a waste product of coal combination in thermal power plants. It posses problem for the safe disposal and cause economic loss to the power plants. Thus, utilization of coal ash in large scale geotechnical constructions as a replacement to conventional earth material needs special attention. The inherent strength of coal ash can be improved either by stabilizing the material with cement, lime etc. and by reinforcing the same.

2.2 POND ASH

Pond ash is produced as a result of combination of coal, Fly ash and bottom ash are mixed together with water to form slurry, which is pumped to the ash pond area. In ash pond area, ash gets settled and excess water is decanted. This deposited ash is called pond ash. This is used as filling materials including in the construction of roads & embankments. Selected pond ash is used for manufacturer of building products like lime fly ash bricks/ blocks etc.

Among the industries thermal power plants are the major contributor of pond ash. Besides, this steel, copper and aluminum plants also contribute a substantial amount of pond ash.

2.3 SOURCE OF COAL ASH IN INDIA

According to Central Electricity authority of India, there are around 83 major coal fired thermal power plants and 305 hydro plants existing in India. As per the ministry of power statistics, the total installed generating capacity (Thermal + wind) during 2003-2004 was about 79838 MW and hydropower generation was 29500 MW. In addition to this, there are more than 1800 selected industrial units which had captive thermal power plants of >1MW.
Some of the prominent Power Plants which are also producing and providing good quality Fly Ash include the following:

Ropar

Kota

Annapara

Dadri

Rihand

Singrauli

Unchahar

Chandrapur

Dahanu

Trombay

Vindyanchal

Raichur

Ramagundam

Korba

2.4 PRESENT SCENARIO ON FLY ASH IN INDIA

- Over 75% of the total installed power generation is coal-based
- 230 - 250 million MT coal is being used every year
- High ash contents varying from 30 to 50%
- More than 110 million MT of ash generated every year
- Ash generation likely to reach 170 million MT by 2010
- Presently 65,000 acres of land occupied by ash ponds
- Presently as per the Ministry Of Environment & Forest Figures, 30% of Ash
- Is being used in Fillings, embankments, construction, block & tiles, etc.

2.5 ASH COLLECTION

Ash can be collected in following categories:-

Dry Fly Ash

Dry ash is collected from different rows of electrostatic precipitators. It is available in two different grades of fineness in silos for use as resource material by different users.

Bottom Ash

Bottom ash is collected from the bottom of the boiler and transported to hydro bins and then ash mound for use in road embankment.

Conditioned Fly Ash

Conditioned fly ash is also available in ash mound for use in land fills and ash building products.

2.6 SOURCE OF FLY ASH

Ash Content in Indian Coal

The quality of coal depends upon its rank and grade. The coal rank arranged in an ascending order of carbon contents is:

Lignite --> sub-bituminous coal --> bituminous coal --> anthracite

Indian coal is of mostly sub-bituminous rank, followed by bituminous and lignite (brown coal). The ash content in Indian coal ranges from 35% to 50%.

The coal properties including calorific values differ depending upon the colliery. The calorific value of the Indian coal (~15 MJ/kg) is less than the normal range of 21 to 33 MJ/Kg (gross).

According to ***National Thermal Power Corporation (****NTPC)*, coal is used for approximately 62.3% of electric power generation in India, oil and gas accounts for 10.2%, hydro's share is 24.1%, nuclear, wind, and other contribute remaining 3.4%.

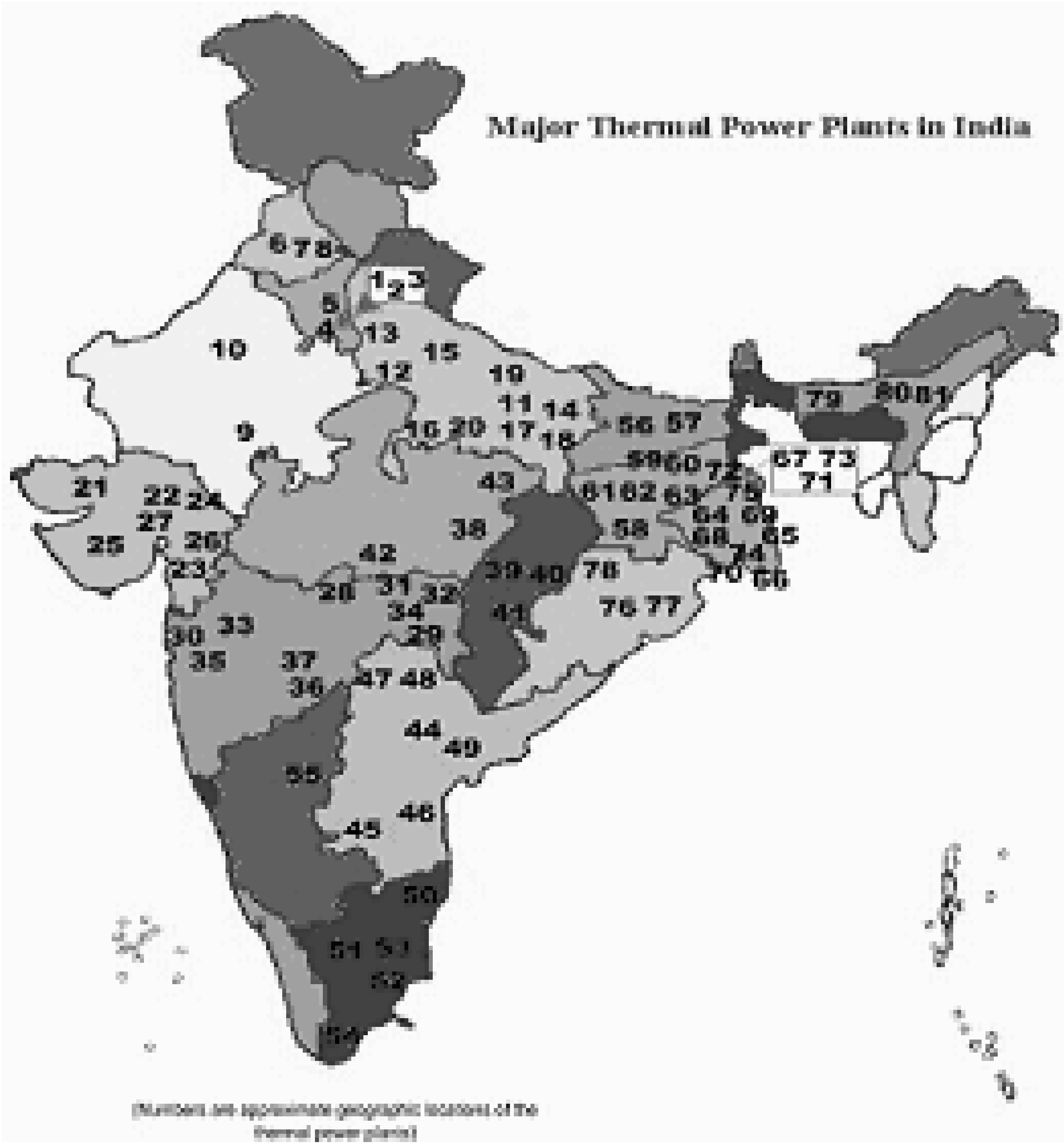

Fig.2.1Geographical location of major thermal power plants in India[9]

2.7 Current coal Ash Generation in India

The current electricity generation (as on March 31, 2004) in India is about 1,12,058 MW, 65-70% of which is thermal (mostly coal based). According to an estimate 100,000 MW capacity or more would be required in the next 10 years due to continually increasing demand for electricity. In India fly ash generation is around 110 million tonnes / year and is set to continue at a high rate into the foreseeable future. Presently majority of the coal ash generated is being handled in wet form and disposed off in ash ponds which is harmful for the environment and moreover ash remains unutilized for gainful applications. India has sufficient coal reserves. In India almost 65-70% of electricity production is dependent on coal which produces a huge quantity of Fly Ash as residue which is allegedly a waste product in Thermal Power Stations. Fly Ash has a vast potential for use in High Volume fly ash concrete especially due its physic-chemical properties. A good amount of research has already been done in India and abroad on its strength and other requisite parameters. Current fly ash generation and utilization in six major states; Gujarat, Maharashtra, Tamil Nadu, Rajasthan, Andhra Pradesh and Uttar Pradesh is presented in the present report. Presently, out of 110 million tonnes of Total ash generated, about (30%) is being utilized.

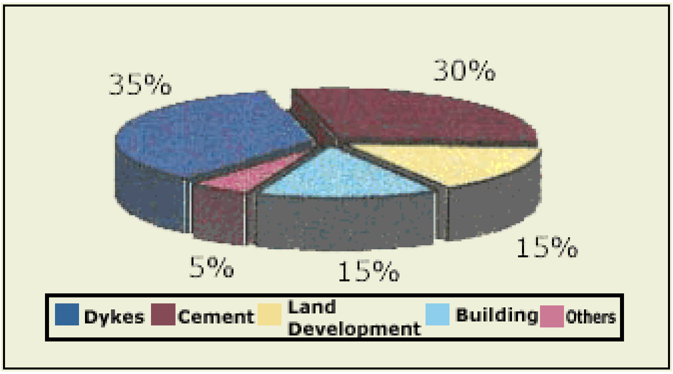

Fig.2.2 Current ash utilization in India[9]

Table 2.1 Chemical composition of pond ash

COMPOUNDS	% IN POND ASH
SiO_2	37.7-75.1
Al_2O_3	11.7-53.3
TiO_2	0.2-1.4
Fe_2O_3	3.5-34.6
MnO	*BD-0.6
MgO	0.1-0.8
CaO	0.2-0.6
K_2O	0.1-0.7
Na_2O	0.05-0.31
LOI	0.01-20.9

*Below Detection; LOI –loss on ignition

- SEM studies carried out to have a closer view of the individual particles of coal ashes show that fly ashes are fine particles compared to bottom ashes. Pond ashes consist of both finer and coarser particles. Investigations at IISc show that the coal ash particles are generally cenospheres leading to low values for specific gravity. They also confirm that fly ash particles are finer compared to bottom ash particles and the pond ash particles are sized in between fly and bottom ashes.

2.8 Chemical properties

The chemical properties of the coal ashes greatly influence the environmental impacts that may arise out of their use/disposal as well as their engineering properties. The adverse impacts include contamination of surface and subsurface water with toxic heavy metals present in the coal ashes, loss of soil fertility around the plant sites, etc. Hence this calls for a detailed study of their chemical composition, morphological studies, pH, total soluble solids, etc.

2.9 SCOPE OF THE WORK

In India there has been very little work regarding use of coal ash. We have 3 categories in coal ash:

- **Bottom Ash**: - Ash collected at the bottom of boiler furnace characterized by better geo- technical properties is termed as bottom ash. It is a good material for fill, road and embankment construction.
- **Fly Ash**: - Ash collected from different rows of Electro-static precipitators in dry form is termed as fly ash. It is used in the manufacture of PCC, Concrete & Cement mortar, Lime fly ash bricks, Building blocks, Aerated concrete blocks etc.
- **Pond Ash**: - Fly ash and bottom ash are mixed together with water to form slurry, which is pumped to the ash pond area. In ash pond area, ash gets settled and excess water is decanted. This deposited ash is called pond ash. This is used as filling materials including in the construction of roads & embankments. Selected pond ash can be used for manufacturer of building products like lime fly ash bricks/ blocks etc.

This experimental work presents the study on compaction characteristics and shear parameters of pond ash. Under this work a number of experiments have been done to study the above. The effects of different compaction and shear controlling parameters, viz compaction energy, moisture content, dry density are highlighted herein. The maximum dry density and optimum moisture content of pond ash vary within the range of 1.09 gm/cc- 1.27 gm/cc and 28%-39% respectively. In the present investigation, the degree of saturation at optimum moisture content of pond ash has been found to vary within the range of 72-80%.. Graphs have been plotted and conclusions have been extracted.

CHAPTER 3

EXPERIMENTAL WORK

EXPERIMENTAL WORK

3.1 INTRODUCTION

The current practice in some power plants is to use large ash ponds, Nearly 70,000 acres of land are presently occupied by ash ponds. In the present study an experimental work was conducted to evaluate the compaction characteristics and shear parameters of pond ash. The index as well as engineering properties have been evaluated. Details of material used, processing test procedure adopted are described in this chapter.

The experiments which were performed:-

1) Density bottle test to determine specific gravity.

2) Sieve analysis and hydro meter tests to find grain size distribution.

3) Compaction tests for different compactive efforts.

4) Direct shear test.

5) Unconfined compression test.

3.2 SAMPLE MATERIAL

The present samples are obtained from ash ponds of DITE C, CPP-2 NSPCL, Rourkela. The samples were oven dried at the temperature of 105-110 degrees. Then it was sieved using 2 mm sieve .the material passing through 2 mm sieve was used in experimental work.

3.3 DETERMINATION OF INDEX PROPERTIES

3.3.1 Specific Gravity:

The specific gravity of fly ash was determined as per IS: 2720 (Part III section 1) 1980 and was obtained to be 2.37

3.3.2 Determination of Grain Size Distribution:

For determination of grain size distribution, the fly ash of 1 kg was washed thoroughly through an IS test sieve having opening size of 75 microns.

Sample taken for sieve analysis =500 gm

TABLE 3.1 SIEVE ANALYSIS OF POND ASH

Size of sieve	Wt of retained particles (gms)
2.00 mm	0
1.00 mm	2.15
425 micron	28.00
212 micron	120.37
150 micron	75.20
75 micron	132.50
In pan	135.20
TOTAL	493.50

MASS LOSS DURING SIEVE ANALYSIS = 500-493.5/500

=1.3 % (OK if less than 2 %)

3.4 DETERMINATION OF ENGINEERING PROPERTIES

3.4.1Moisture content and dry density through compaction tests

Experimental set up:

The moisture content, dry density relationships were found by using compaction tests as per IS: 4332 (part III). For this test pond ash was mixed with water and the mixture was compacted in proctor mould in some specified equal layers (eg. 3 for standard proctor and 5 for modified proctor) applying s number of blows to each layer (eg. 25 blows) by standard proctor rammer of 2.6 kg and modified proctor rammer of 4.5 kg as per requirement of compactive effort with a free fall of 310mm for standard proctor rammer and 450 mm for modified proctor rammer. The moisture content of the compacted mixture was determined as per IS: 2720 (part VII) 1985. From the dry density and moisture content relationship, OMC and MDD are determined. Similar compaction tests were conducted on various sample of pond ash in order to evaluate the affect of compactive energy on the OMC and MDD on the compacted mixture.

Table 3.2 Compaction Characteristics of Pond Ash

Sl no	Compaction energy (kg-cm)	OMC (%)	MDD (gm/cc)	Degree of saturation
1	3639	38.82	1.09	0.8
2	6065	35.91	1.10	0.752
3	15223	31.38	1.16	0.729
4	27260	28.30	1.24	0.756
5	28444	28.18	1.26	0.796
6	35554	28.09	1.27	0.792

3.4.2 Measurement of shear parameters through direct shear test

Experimental setup:

Specimens were tested in a 60 mm square and 50 mm deep shear box which is divided into two parts horizontally , with suitable spacing screws at normal stresses of 25 to 100 kPa and sheared at a rate of 1.25 mm/minute according to IS:2720 (Part 13). The resulting peak friction angle and cohesion values were found for different compactive efforts and different moisture content and fixed density and vice versa.

Table 3.3 Shear parameters (at different compactive efforts) of pond ash

Sl no	Compactive effort (kg-cm)	Dry density (gm/cc)	Moisture content (%)	C (kg/ cm^2)	ϕ (degree)
1	3639	1.09	38.82	0.153	21.9
2	6065	1.1	35.91	0.105	20.81
3	15223	1.16	31.38	0.116	21.8
4	27260	1.24	28.30	0.116	23.94
5	28444	1.26	28.12	0.079	20.81
6	35554	1.27	28.09	0.100	23.75

3.4.2.1 Shear parameters (MDD fixed MC changed and OMC fixed DD changed)

Table 3.4 Standard proctor MDD =1.1(gm/cc) OMC = (35.91%)

Sl no	Dry density (gm/cc)	Moisture content (%)	C (kg/sq cm)	ϕ (degree)
1	1.1	55.91	0.0479	13.62
2	1.1	45.91	0.0288	14.57
3	1.1	25.91	0.0216	15.80
4	1.1	20.91	0.0024	15.81

Table 3.5 Modified proctor MDD =1.24(gm /cc) OMC =28.3%

Sl no	Dry density (gm/cc)	Moisture content (%)	C (kg/sq cm)	ϕ (degree)
1	1.24	48.30	0.0455	13.73
2	1.24	38.30	0.0431	14.72
3	1.24	18.30	0.0046	14.17
4	1.24	13.30	0.0264	17.83

Table 3.6 Standard proctor MDD =1.1(gm/cc) OMC = (35.91%)

Sl no	Dry density (gm/cc)	Moisture content (%)	C (kg/sq cm)	ϕ (degree)
1	1.0	35.91	0.001	12.18
2	1.2	35.91	0.0359	15.16

Table 3.7 Modified proctor MDD =1.24(gm /cc) OMC =28.3%

Sl no	Dry density (gm/cc)	Moisture content (%)	C (kg/sq cm)	ϕ (degree)
1	1.14	28.30	0.0335	12.07
2	1.34	28.30	0.0383	12.74

Nomenclature:

MDD: MAXIMAUM DRY DENSITY

OMC: OPTIMUM MOISTURE CONTENT

DD: DRY DENSITY

MC: MOISTURE CONTENT

3.4.3 Measurement of Unconfined Compressive Strength through unconfined compression test

Unconfined compression tests were performed on unreinforced specimens according to IS: 2720 (Part 2). Cylindrical specimens with a height to diameter ratio of 2 (100 mm high × 50 mm diameter) were compressed until failure. Compressive strength was found for different compactive efforts and different moisture content and fixed density and vice versa.

Table 3.8 Compressive strength related to compactive effort

Sl no	Compaction energy (kg-cm)	Compressive strength ,q_u (N/cm^2)
1	3639	0.112
2	6065	0.471
3	15223	0.589
4	27260	0.952
5	28444	1.010
6	35554	1.167

Table 3.9 Compressive strength (MDD fixed moisture content changed)

Sl no.	Type of experiment	Dry density (gm/cc)	Moisture content (%)	Compressive strength (N/cm^2)
1	Standard proc. data	1.1	35.91+10	.158
2	Standard proc. data	1.1	35.91-10	0.7

Table 3.10 Compressive strength (MDD fixed moisture content changed)

3	Modified proc. data	1.24	28.30+10	0.5
4	Modified proc. data	1.24	28.30-10	2.5

CHAPTER 4

TEST RESULTS AND GRAPHS

TEST RESULTS AND GRAPHS

4.1 INTRODUCTION

Pond ash is the by-product of thermal power plants, contains grains of fine sand and silt size. Pond ash is a lightweight and self-draining material compared to natural soil. A conventional way of determining the compaction characteristics ,shear parameters and compression strength is by proctor tests ,direct shear test and unconfined compression test respectively. Under this work a number of experiments have been done to study the above. In this section the experimental results of pond ash are presented. The effects of different compaction and shear controlling parameters, viz compaction energy, moisture content, dry density are highlighted hereinThe discussion on the results obtained from the experiments has been made in this section, highlighting the effects of different parameters item-wise and also with reference to relevant figures.

4.2 INDEX PROPERTIES:

4.2.1 SPECIFIC GRAVITY

The specific gravity of fly ash was determined as per IS: 2720 (Part III section 1) 1980 and was obtained to be 2.37

4.2.2 GRAIN SIZE DISTRIBUTION

Grain size distribution for pond ash is given in table 3.1. the pond ash consists of grains mostly of fine sand to silt size. The grain size distribution of fly ash mostly depends upon the degree of pulverization of coal and the firing temperature in boiling units.

4.2.3 Atterburg limits

It was not possible to find out the liquid limit and plastic limit of pond ash indicating that pond ash is non-plastic in nature

4.3 ENGINEERING PROPERTIES

4.3.1 Compaction Characteristics

The moisture content, dry density relationships were found by using compaction tests as per IS: 4332 (part III). For this test pond ash was mixed with water and the mixture was compacted in proctor mould.compactive energy used was in the range from 3639-35554 kg-cm.fig 4.1 to 4.11 shows the effect of compactive energy on compaction characteristics.

4.1 COMPACTION TEST :

Moisture content dry density relationship:

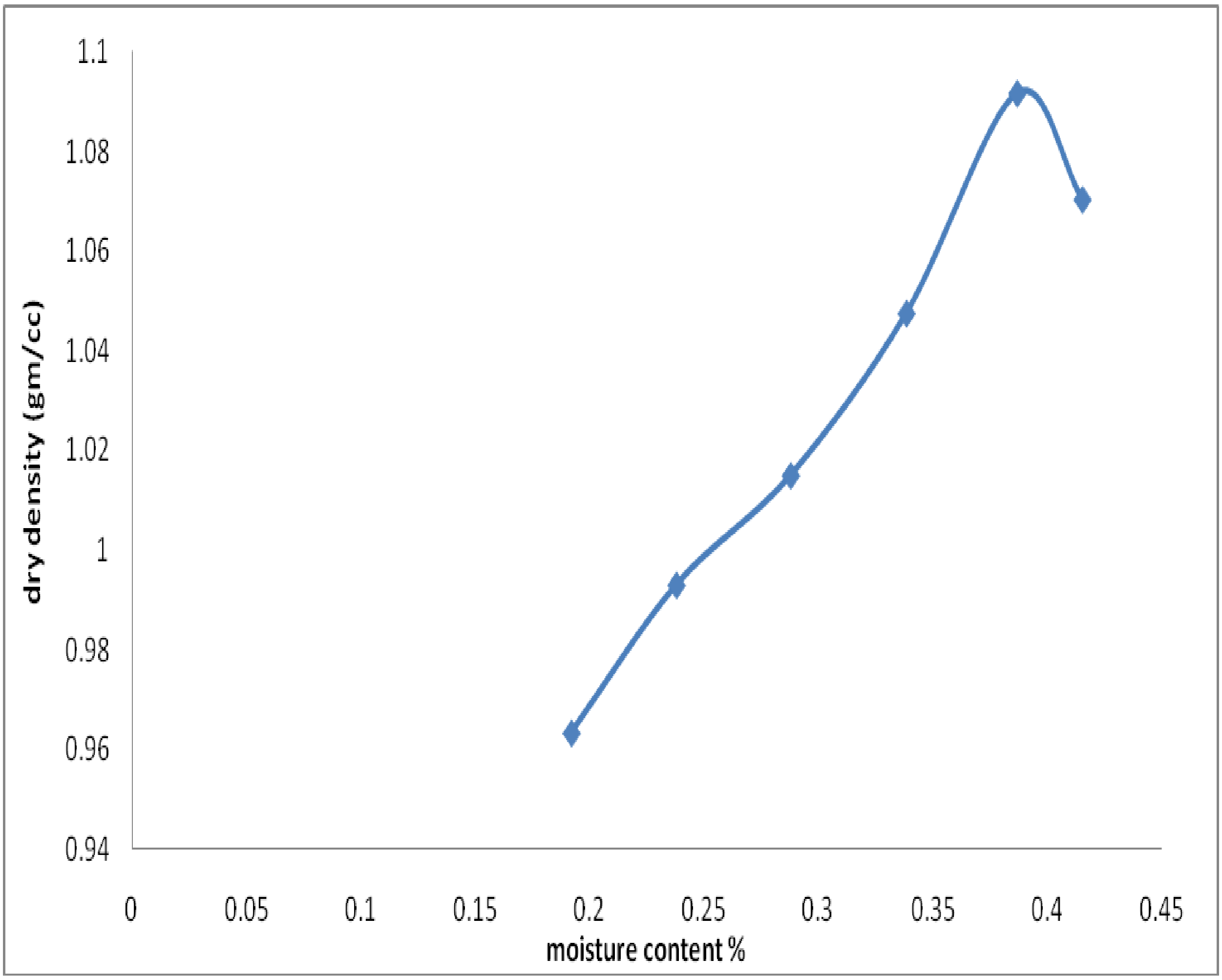

FIG. 4.1 compactive energy 3639Kg-cm

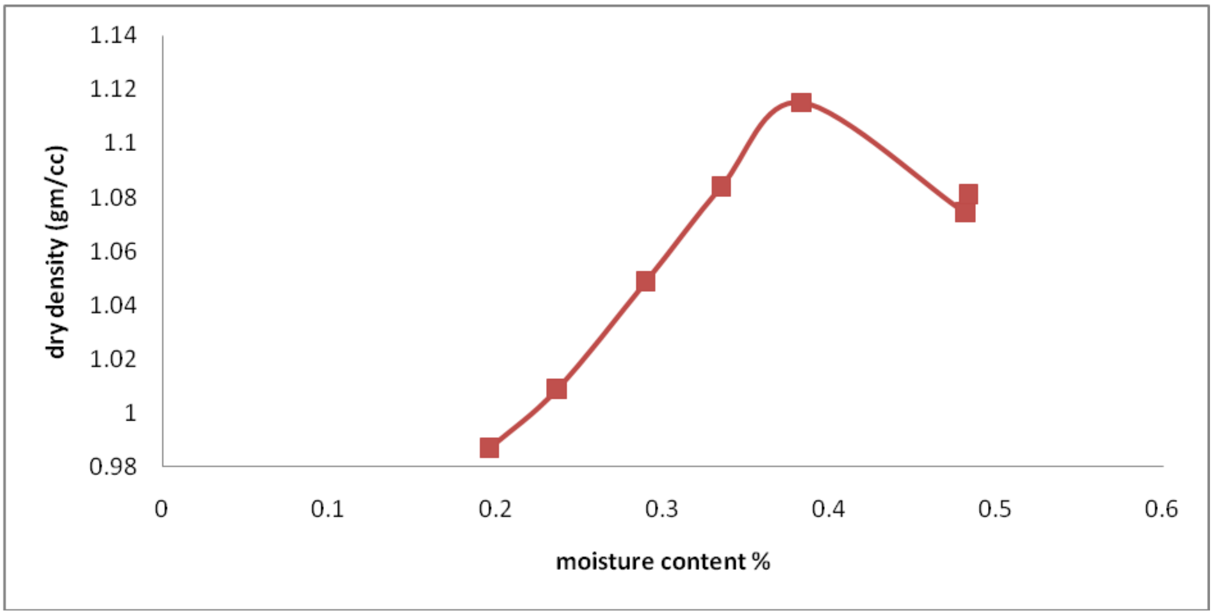

FIG 4.2 compactive energy 6065 Kg-cm

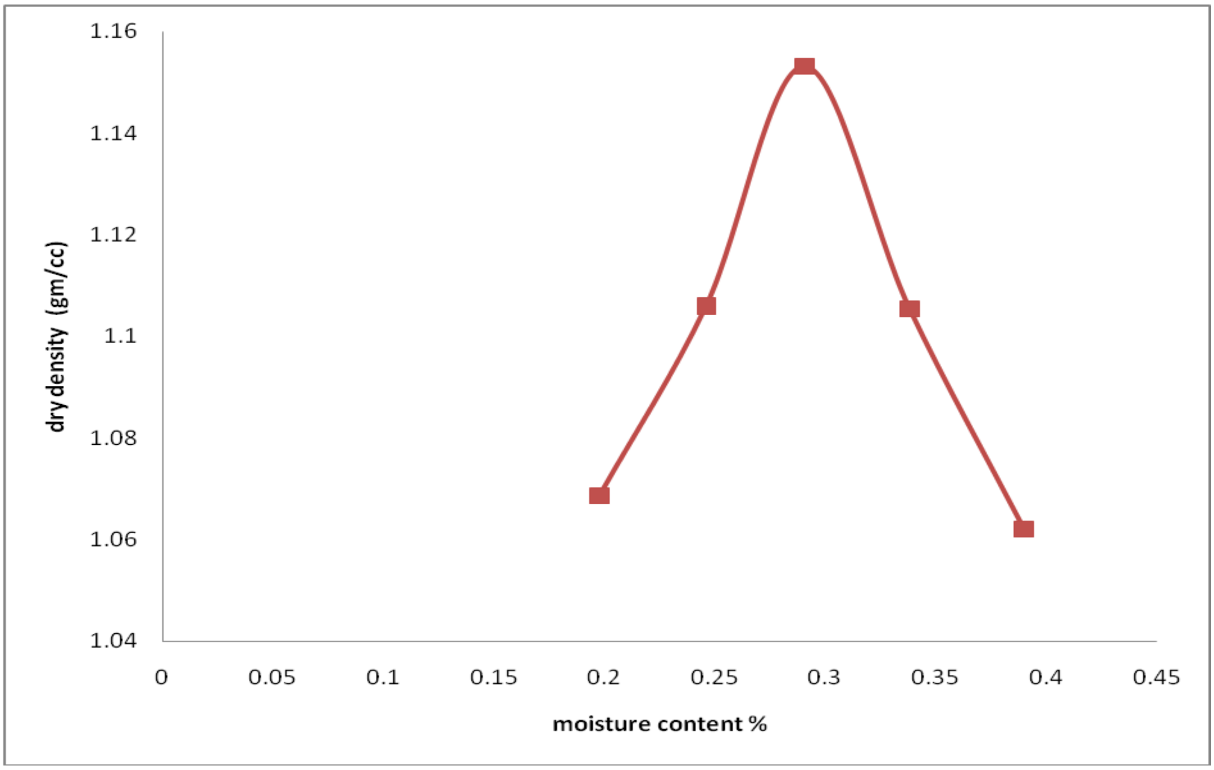

Fig 4.3 compactive energy 15223 Kg –cm

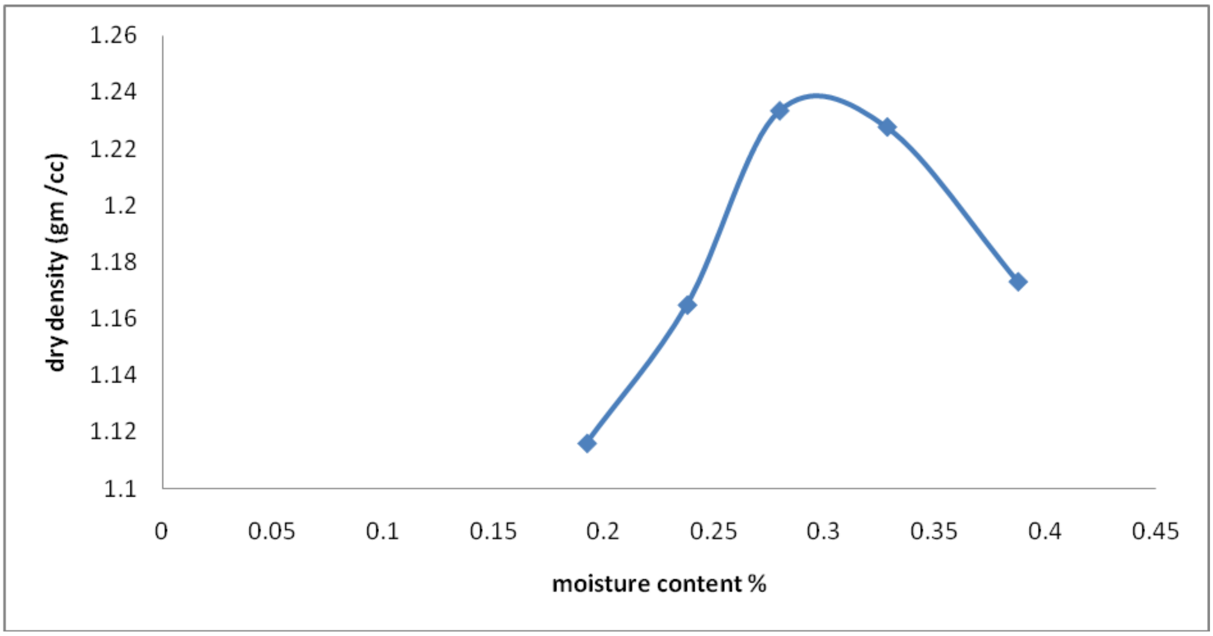

FIG. 4.4 compactive energy 27260 Kg- cm

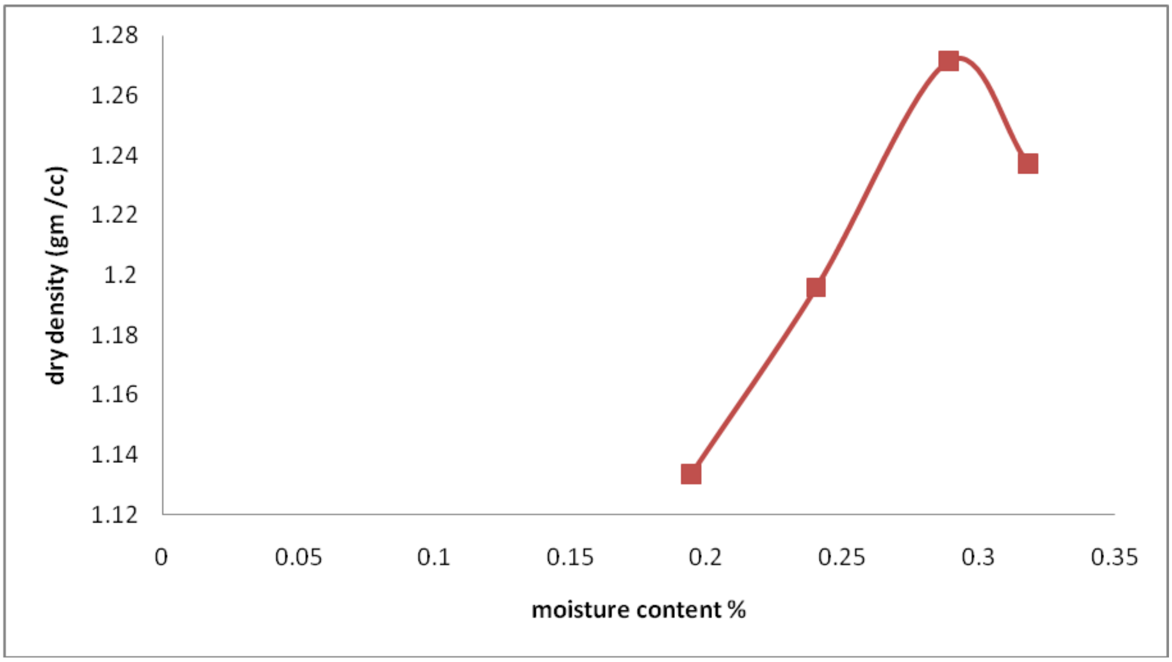

FIG. 4.5 compactive energy 28444 Kg-cm

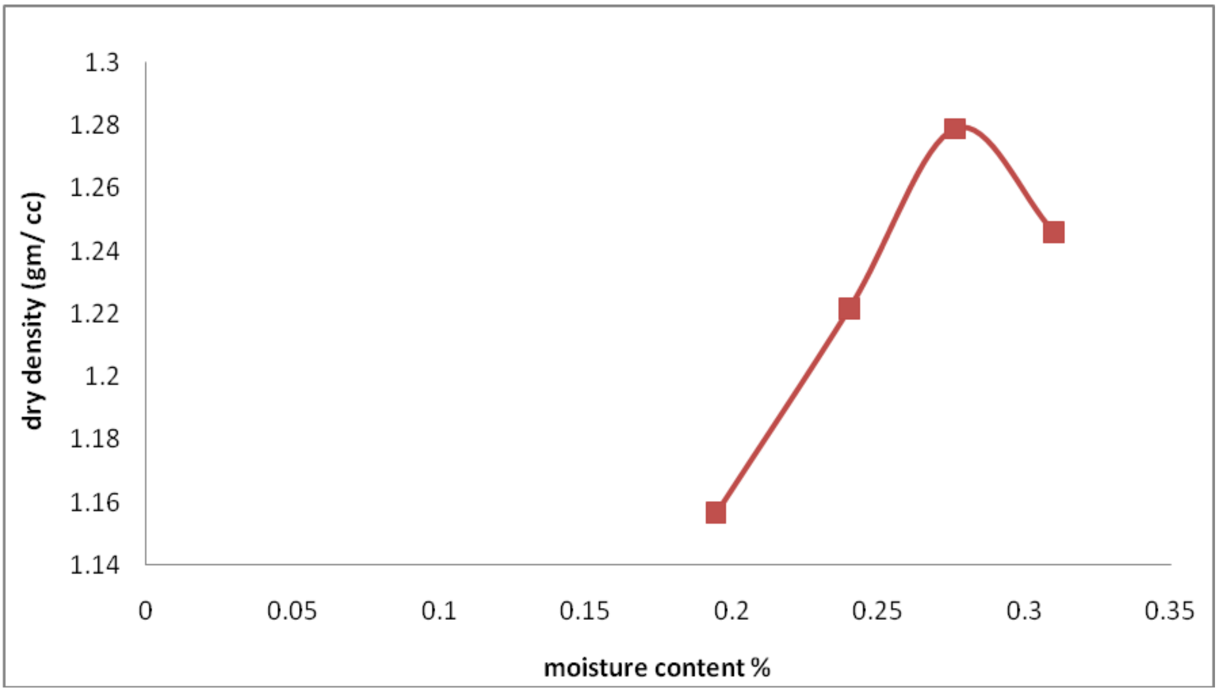

FIG. 4.6 compactive energy 35554 Kg-cm

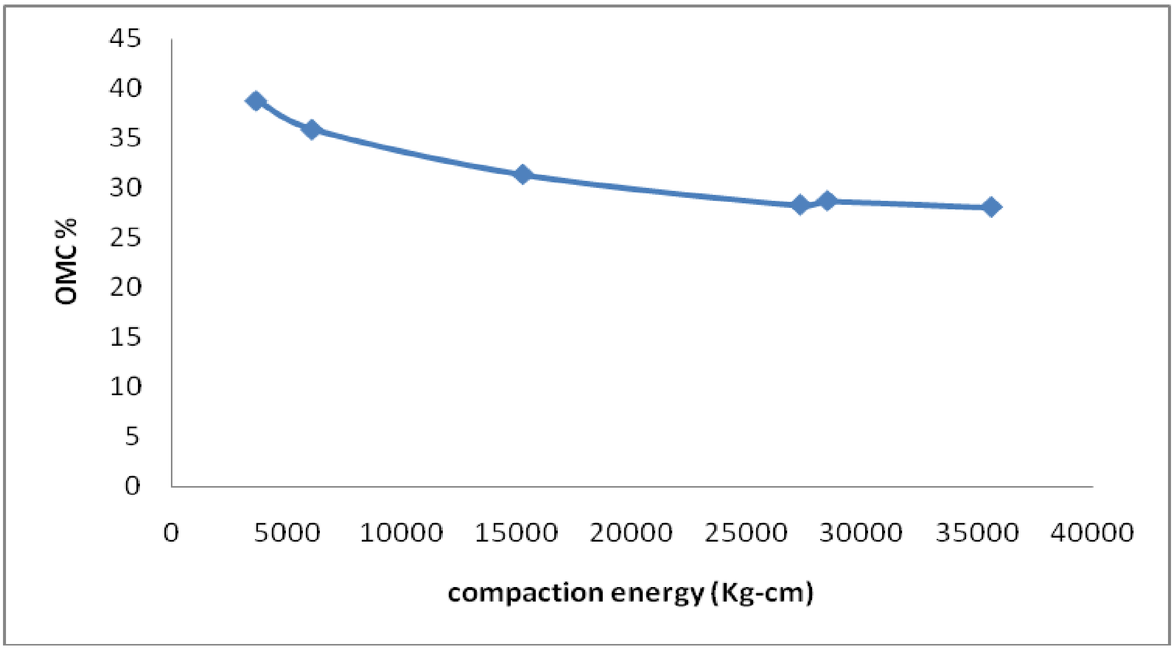

FIG. 4.7

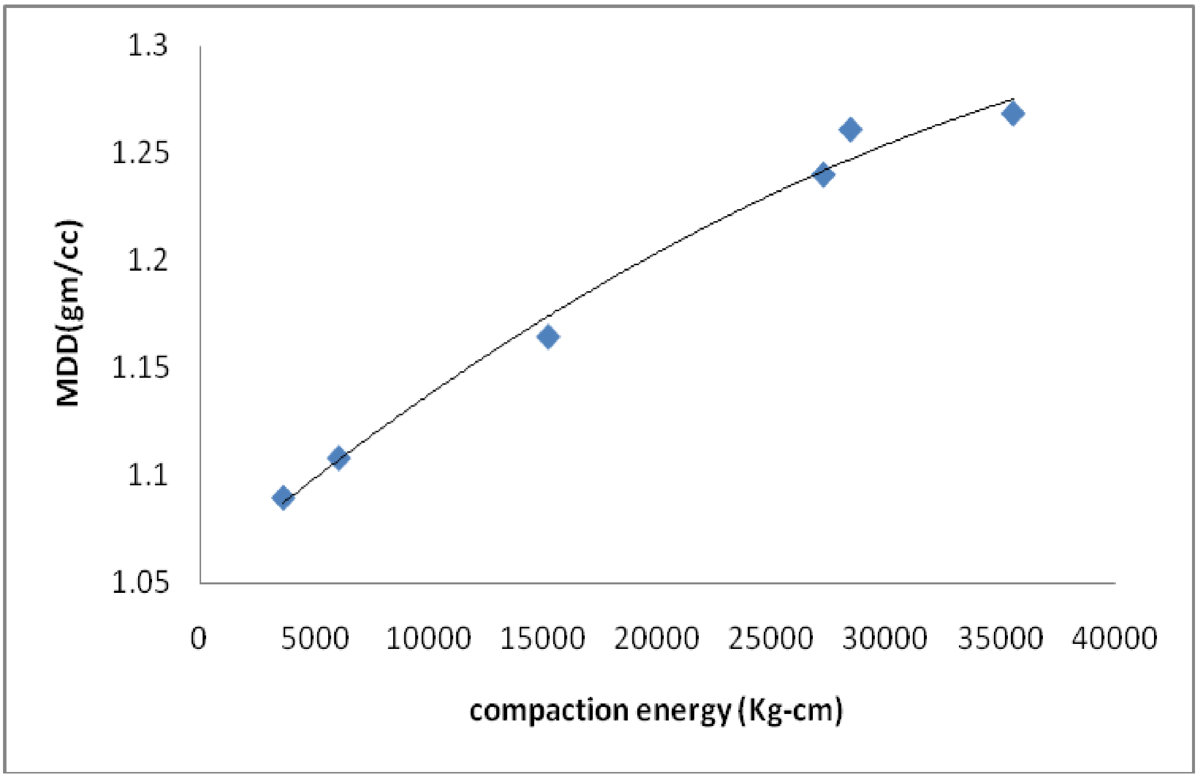
1.3
1.25
1.2
1.15
1.1
1.05
MDD(gm/cc)
0
5000
10000
15000
20000
25000
30000
35000
40000
compaction energy (Kg-cm)

FIG. 4.8

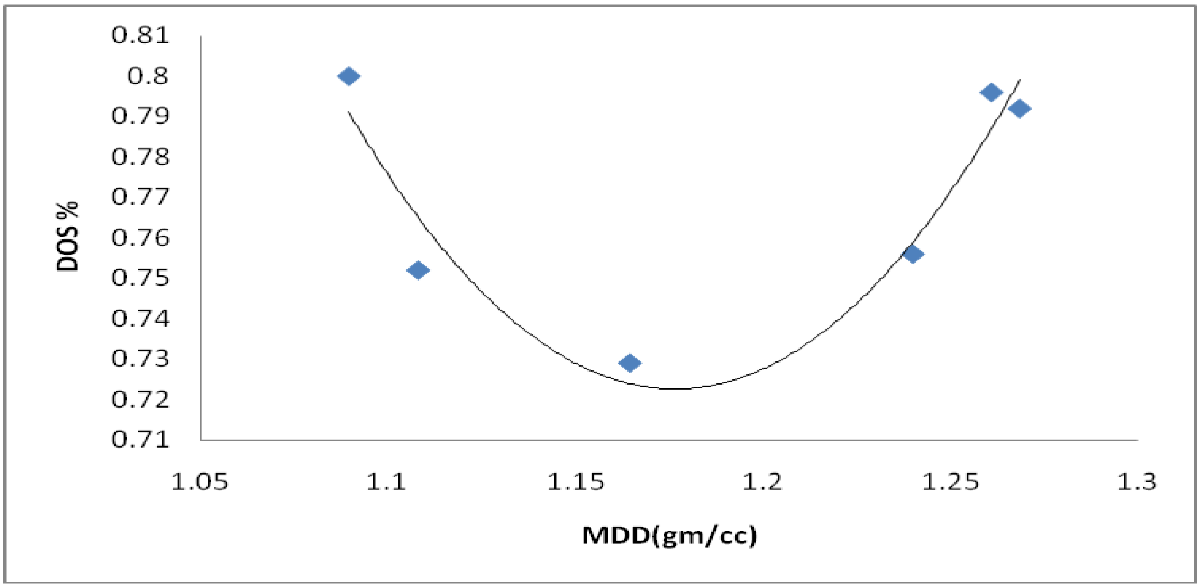
0.81
0.8
0.79
0.78
0.77
0.76
0.75
0.74
0.73
0.72
0.71
DOS %
1.05
1.1
1.15
1.2
1.25
1.3
MDD(gm/cc)

FIG. 4.9

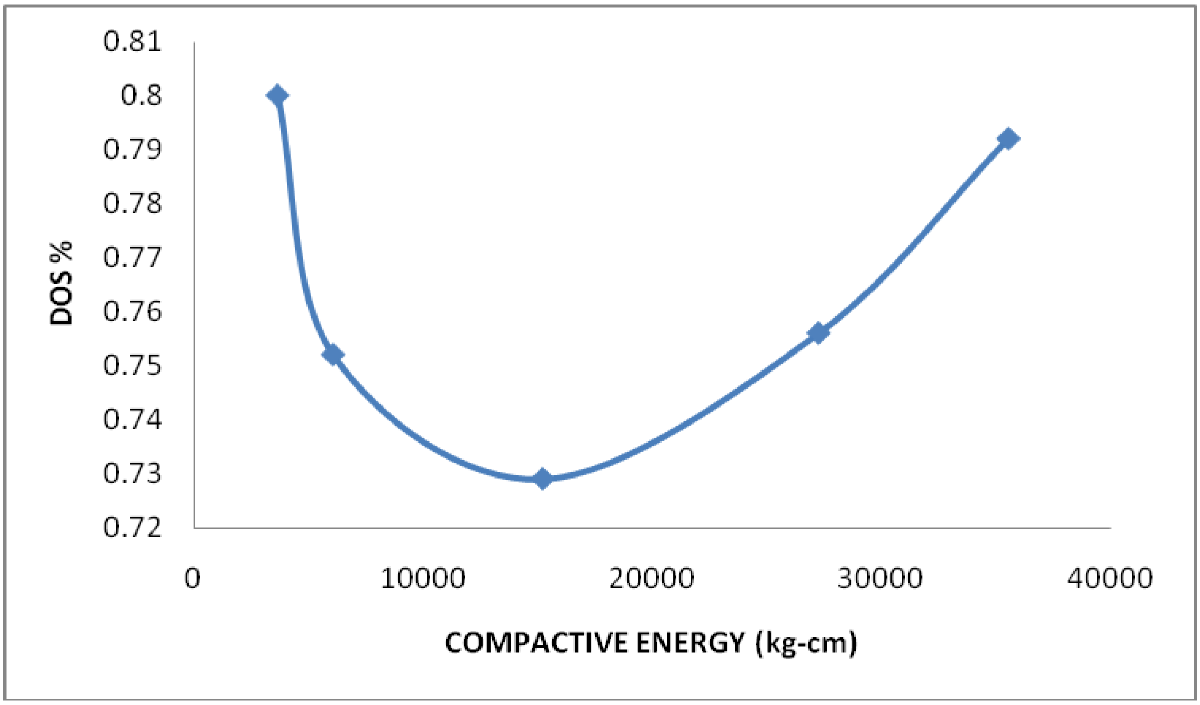

FIG. 4.10

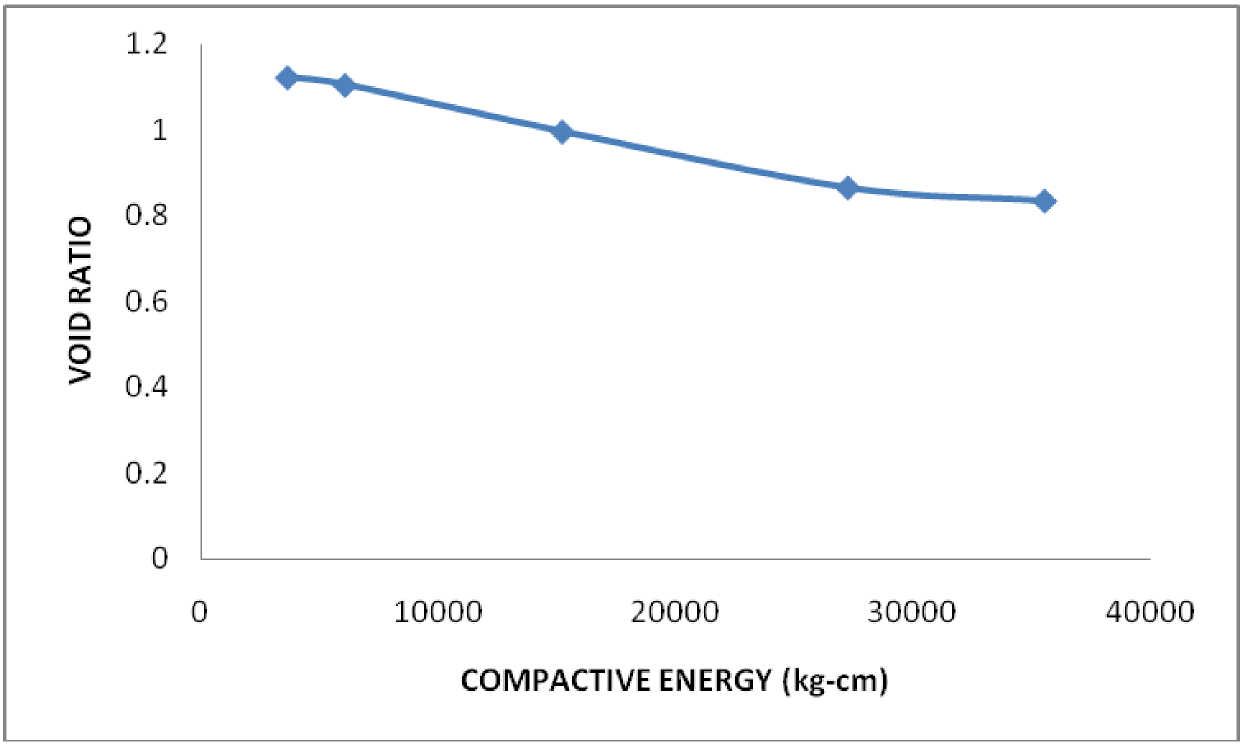

FIG. 4.11

4.2 Direct shear test:

Specimens were tested in a 60 mm square and 50 mm deep shear box which is divided into two parts horizontally , with suitable spacing screws at normal stresses of 25 to 100 kPa and sheared at a rate of 1.25 mm/minute according to IS:2720 (Part 13). The resulting peak friction angle and cohesion values were found. Results are tabulated in table 3.3 to table 3.6. Graphs are plotted in fig 4.12 to fig 4.30.

4.2.1 *Compaction energy variations*

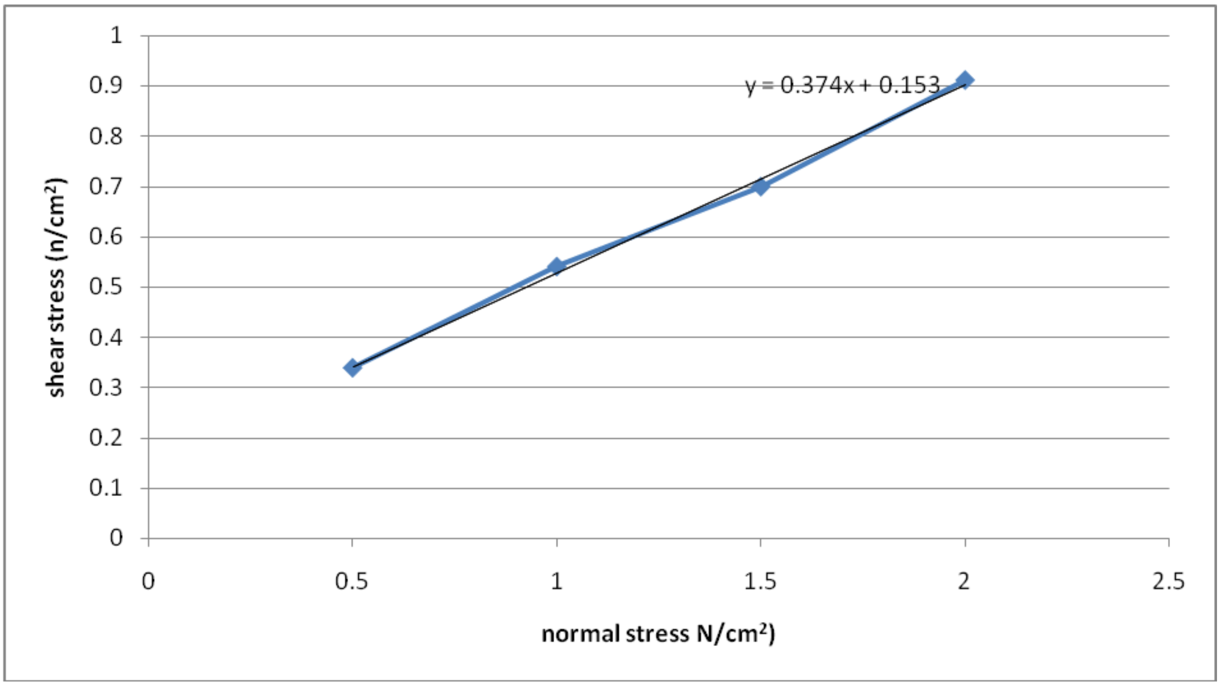

FIG. 4.12 Compactive energy 3639 Kg-cm

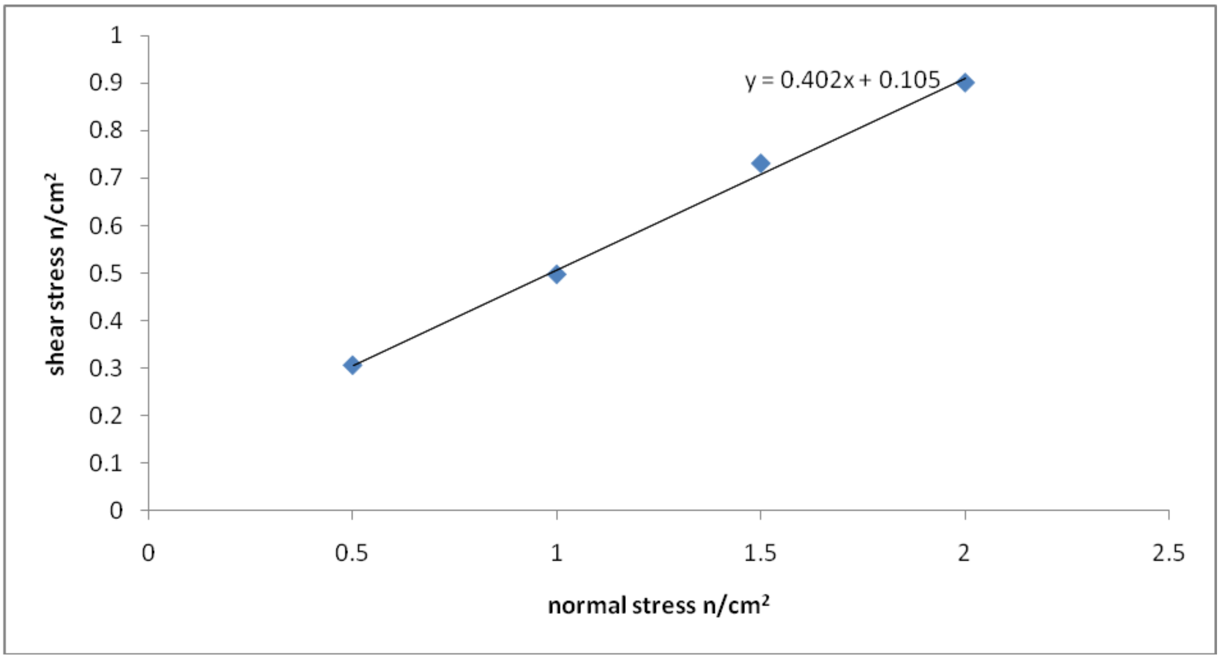

FIG. 4.13 Compactive energy 6065 Kg-cm

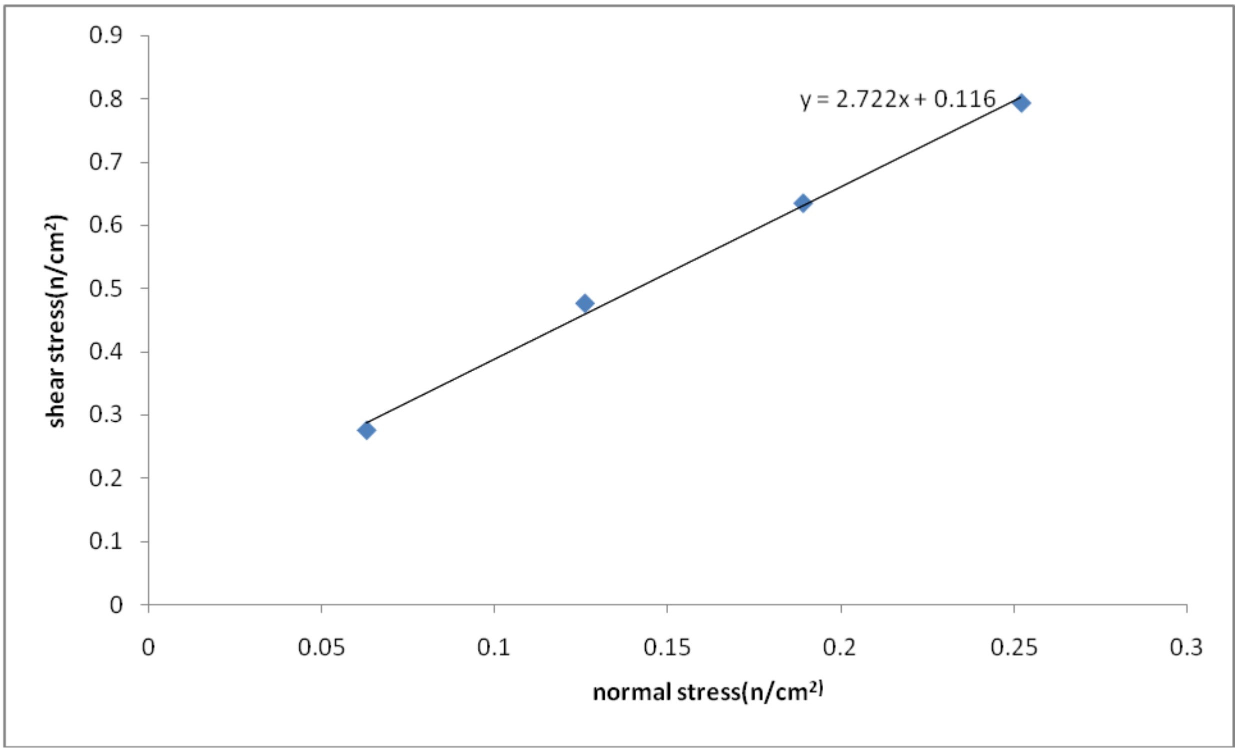

FIG. 4.14 Compactive energy 15223 KJ-cm

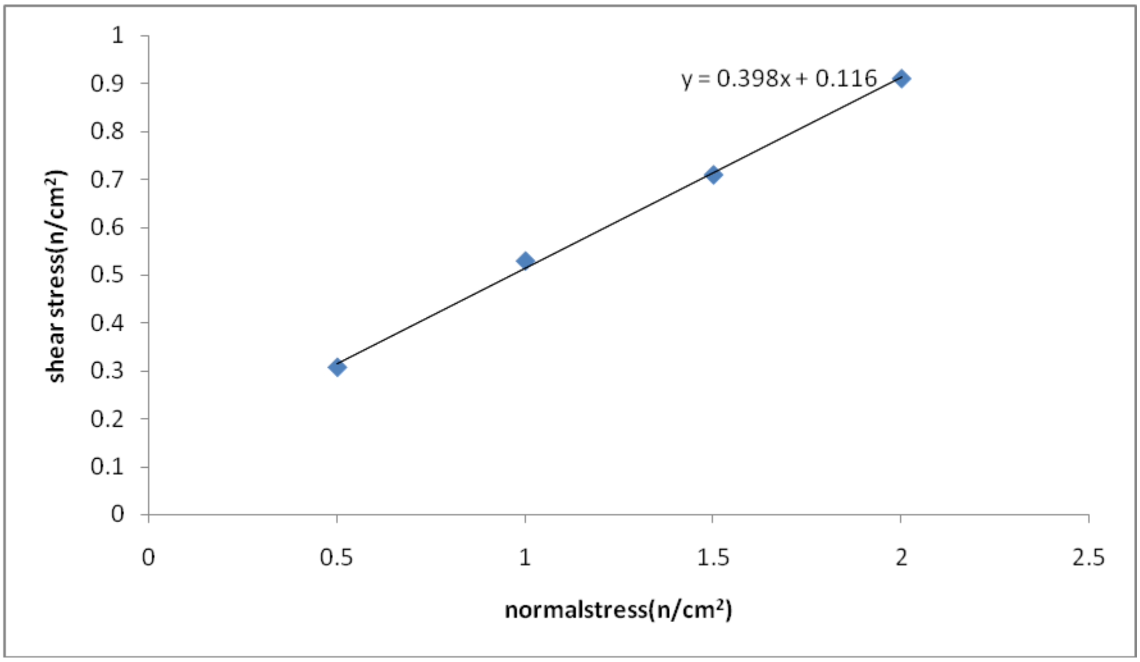

FIG. 4.15 Compactive energy 27260 KJ-cm

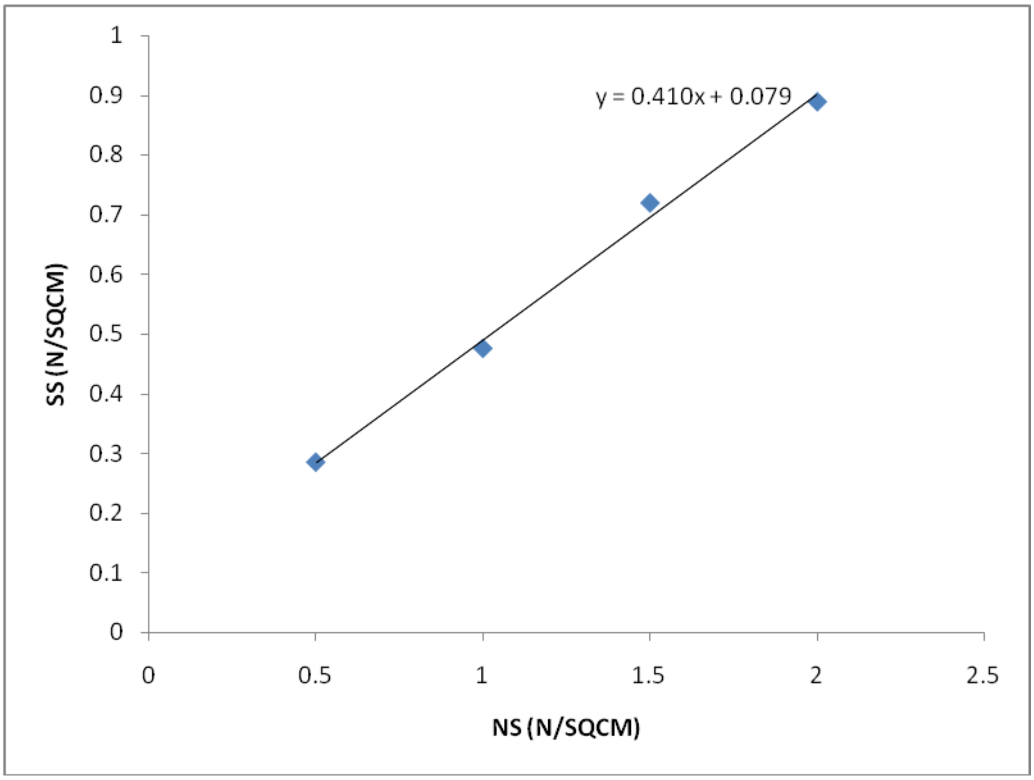

FIG. 4.16 Compactive energy 28444 KJ-cm

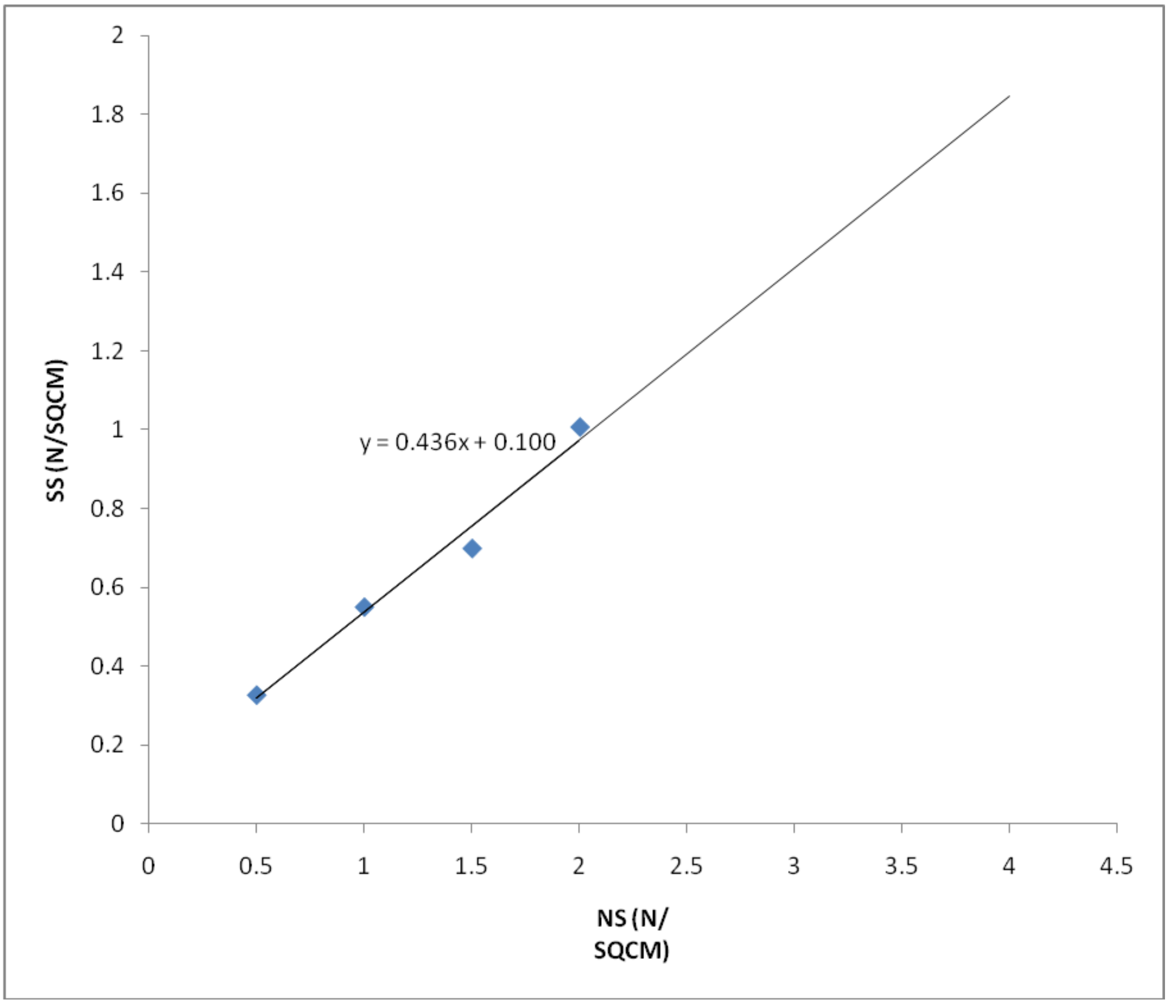

FIG. 4.17 Compactive energy 35554 KJ-cm

__4.2.2 DIRECT SHEAR : MDD FIXED MOISTURE CONTENT VARIED__

Standard proctor (MDD =1.1 gm/cc , OMC= 35.91%)

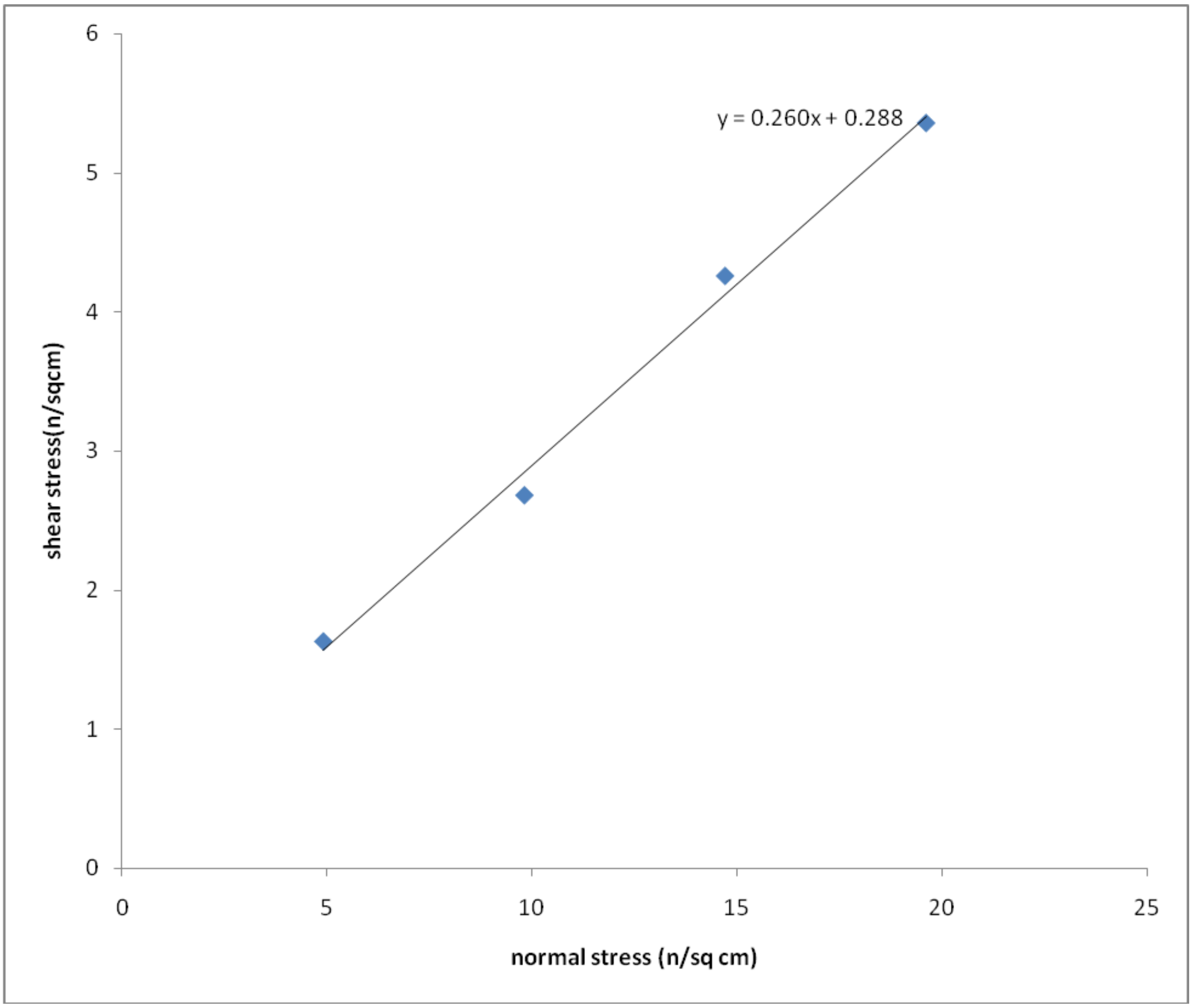

FIG. 4.18   Moisture content 45.91 %

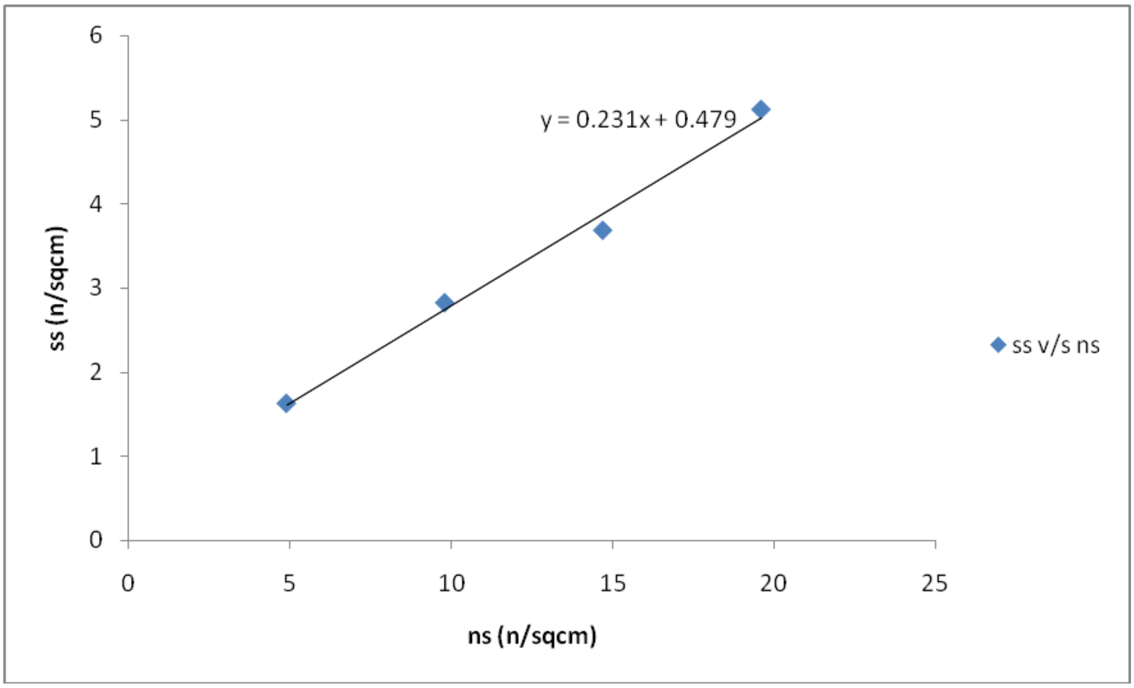

FIG. 4.19 Moisture content 55.91 %

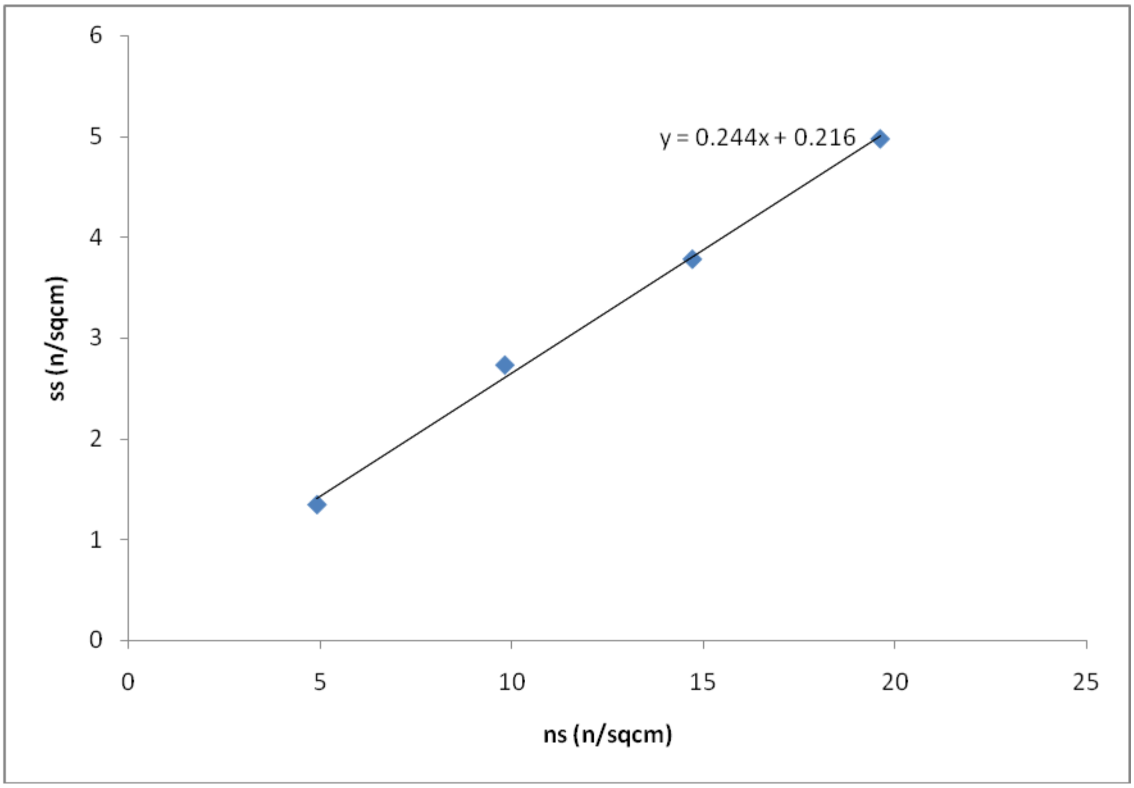

FIG. 4.20 Moisture content 25.91 %

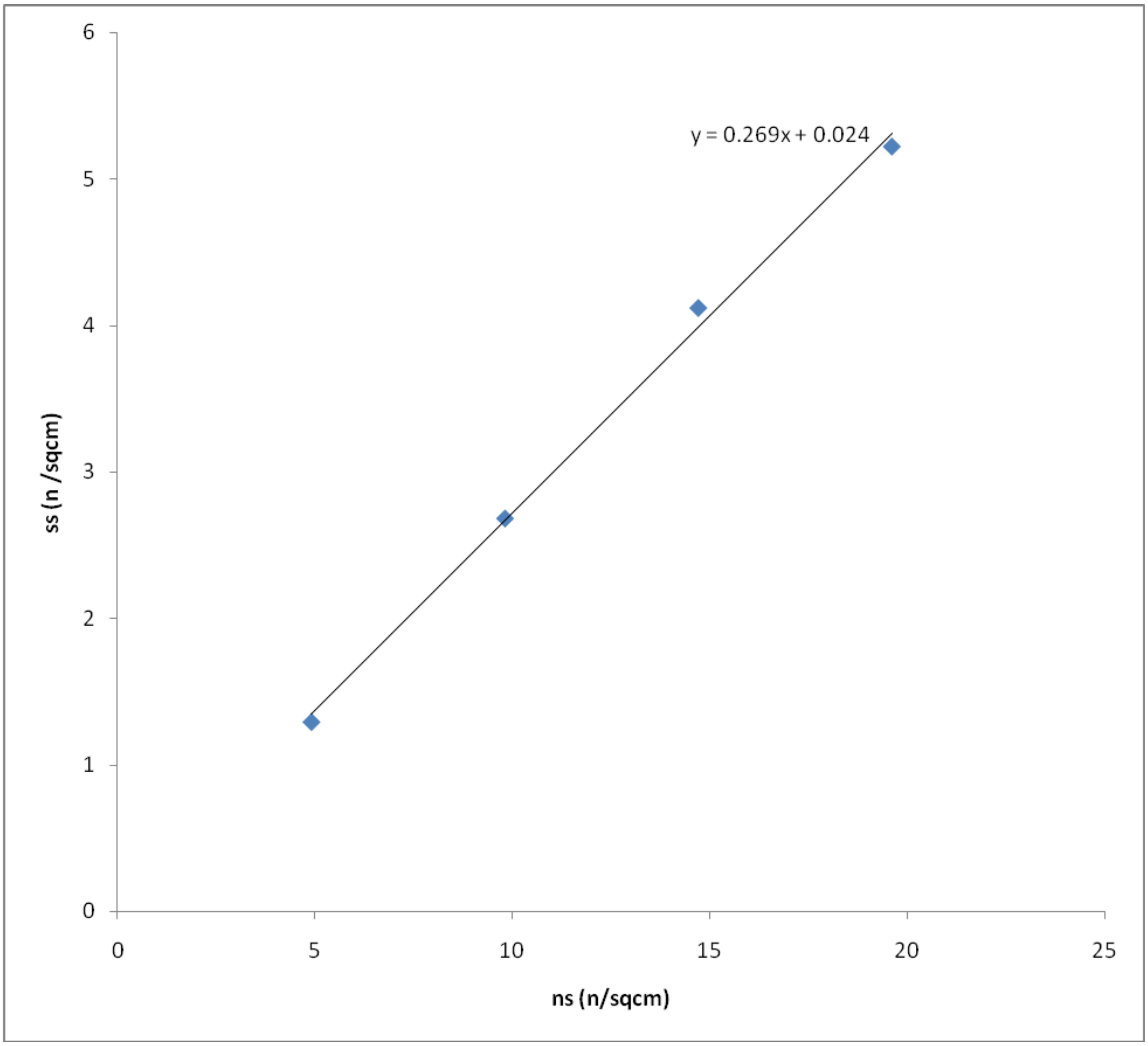

FIG. 4.21 Moisture content 20.91 %

Modified proctor (MDD = 1.24 gm/cc,OMC=28.30%)

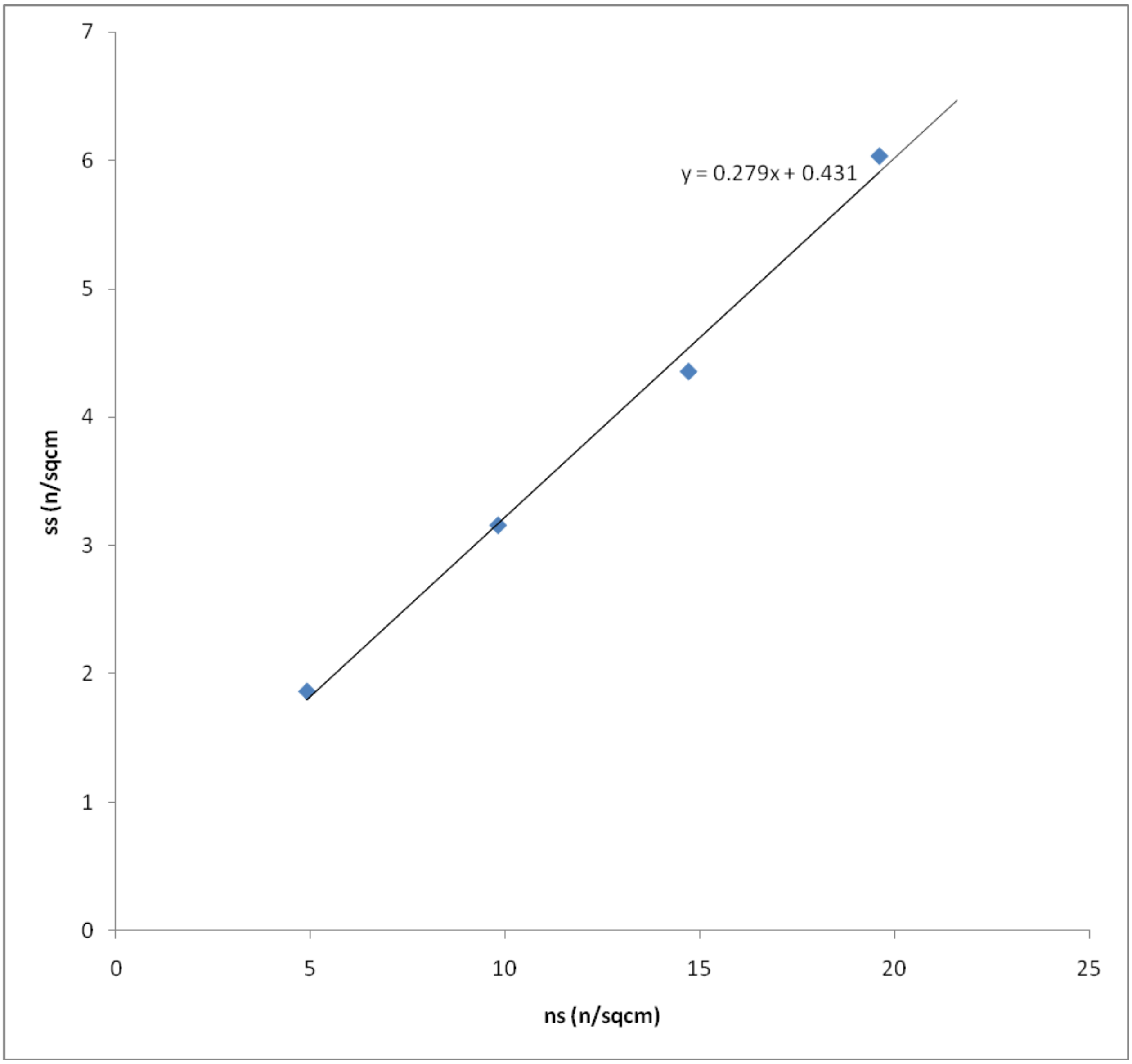

FIG. 4.22 Moisture content 38.30 %

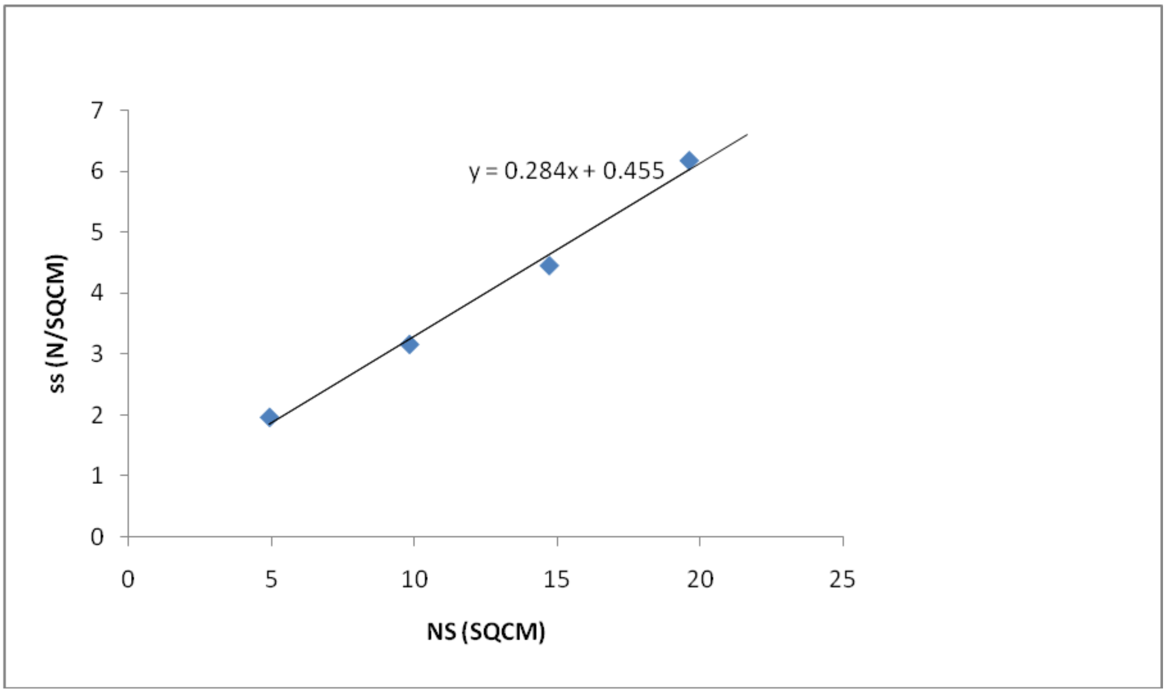

FIG. 4.23 Moisture content 48.30 %

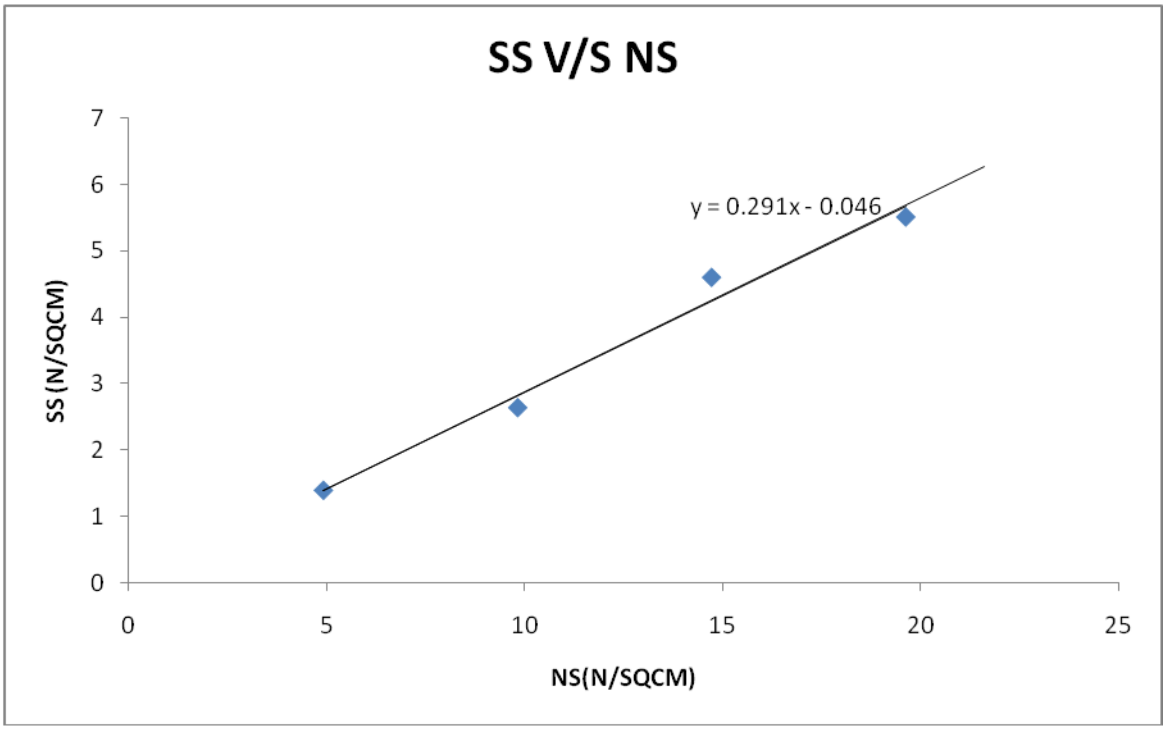

FIG. 4.24 Moisture content 18.30 %

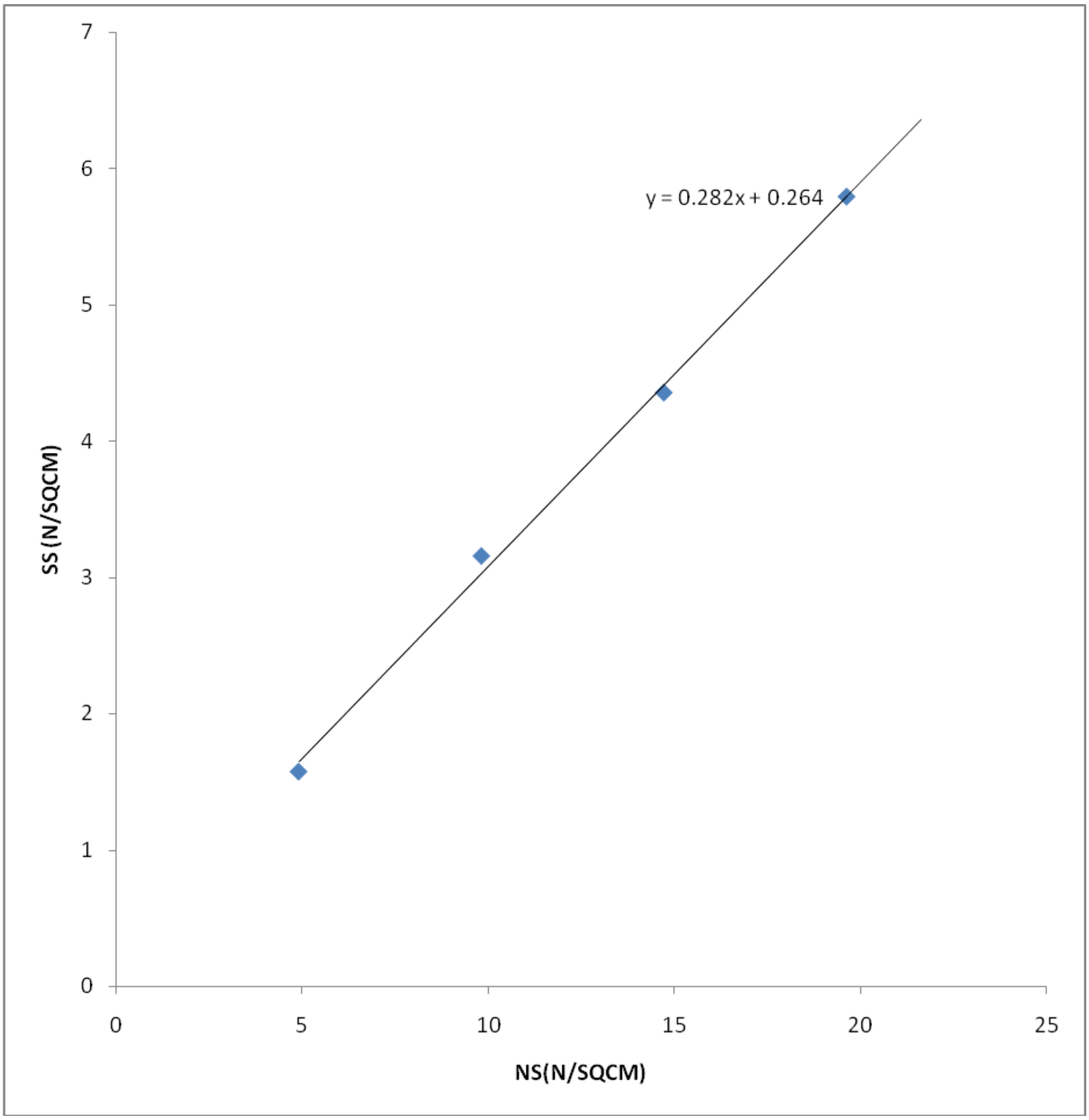

FIG. 4.25 Moisture content 13.30 %

4.2.3 DIRECT SHEAR : MDD VARIED MOISTURE CONTENT FIXED

4.2.3.1 Standard proctor (MDD =1.1 gm/cc , OMC= 35.91%)

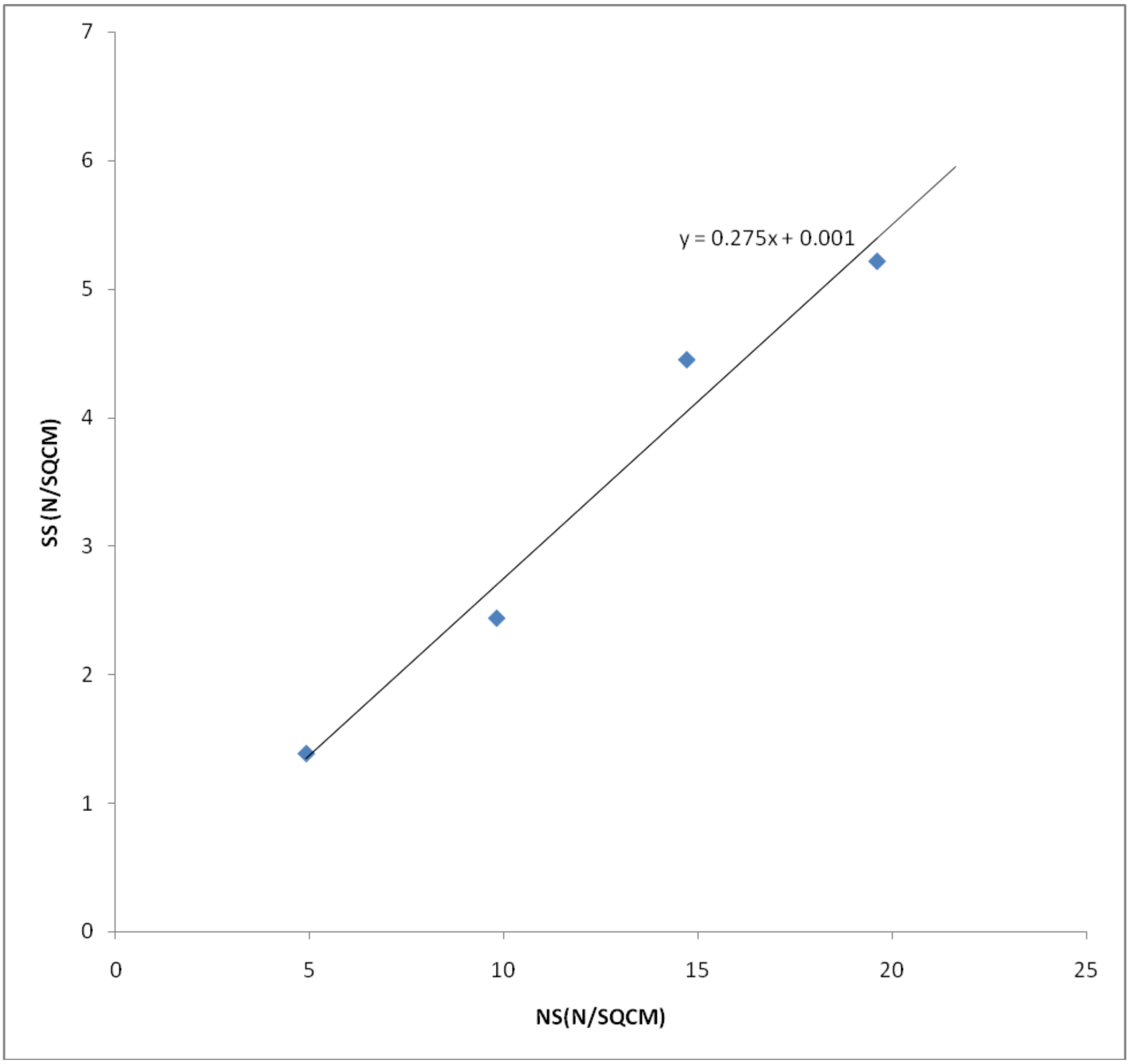

FIG. 4.26 DRY DENSITY 1.00 gm/cc

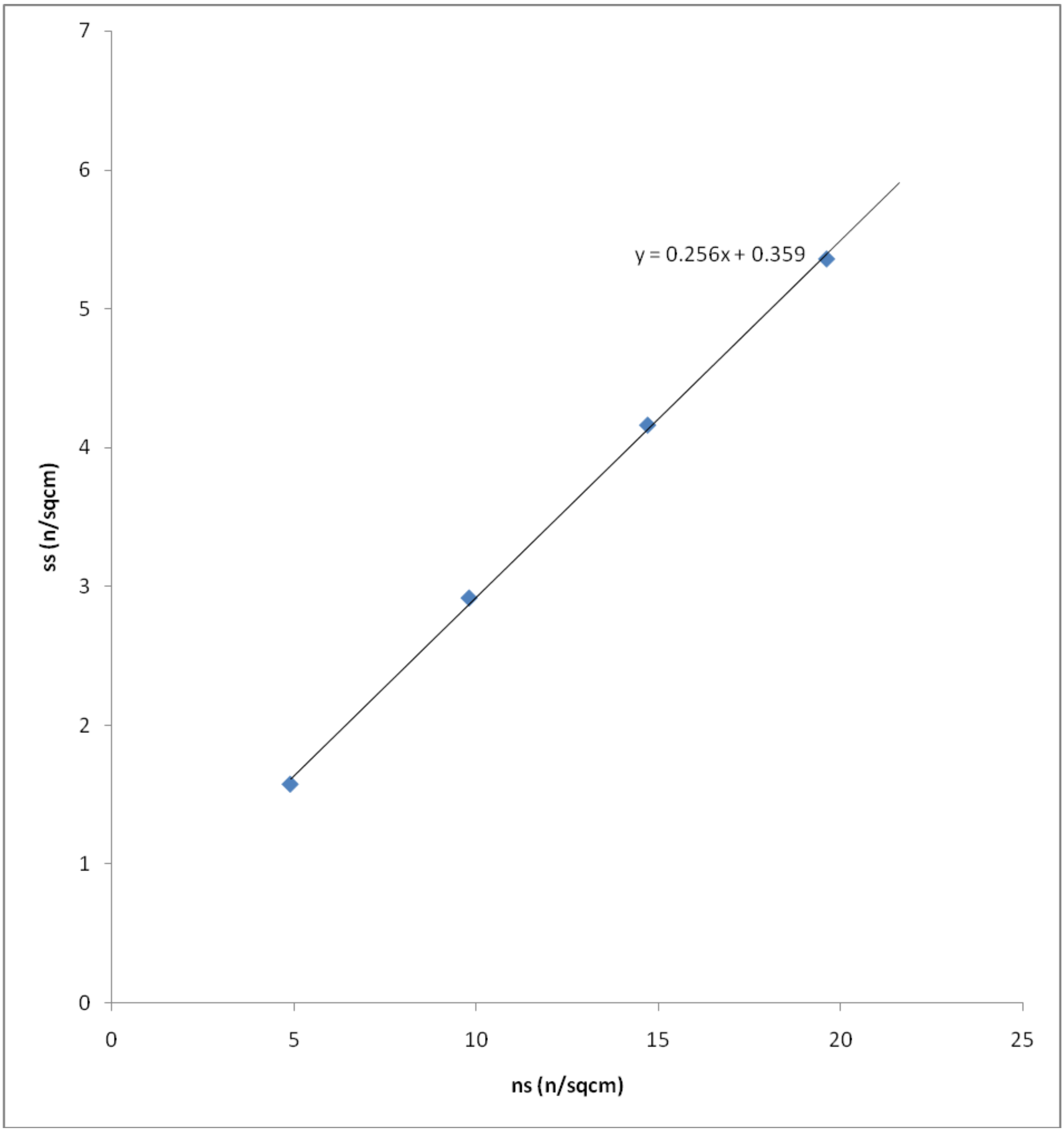

FIG. 4.27 DRY DENSITY 1.20 gm/cc

Modified proctor (MDD = 1.24 gm/cc,OMC=28.30%)

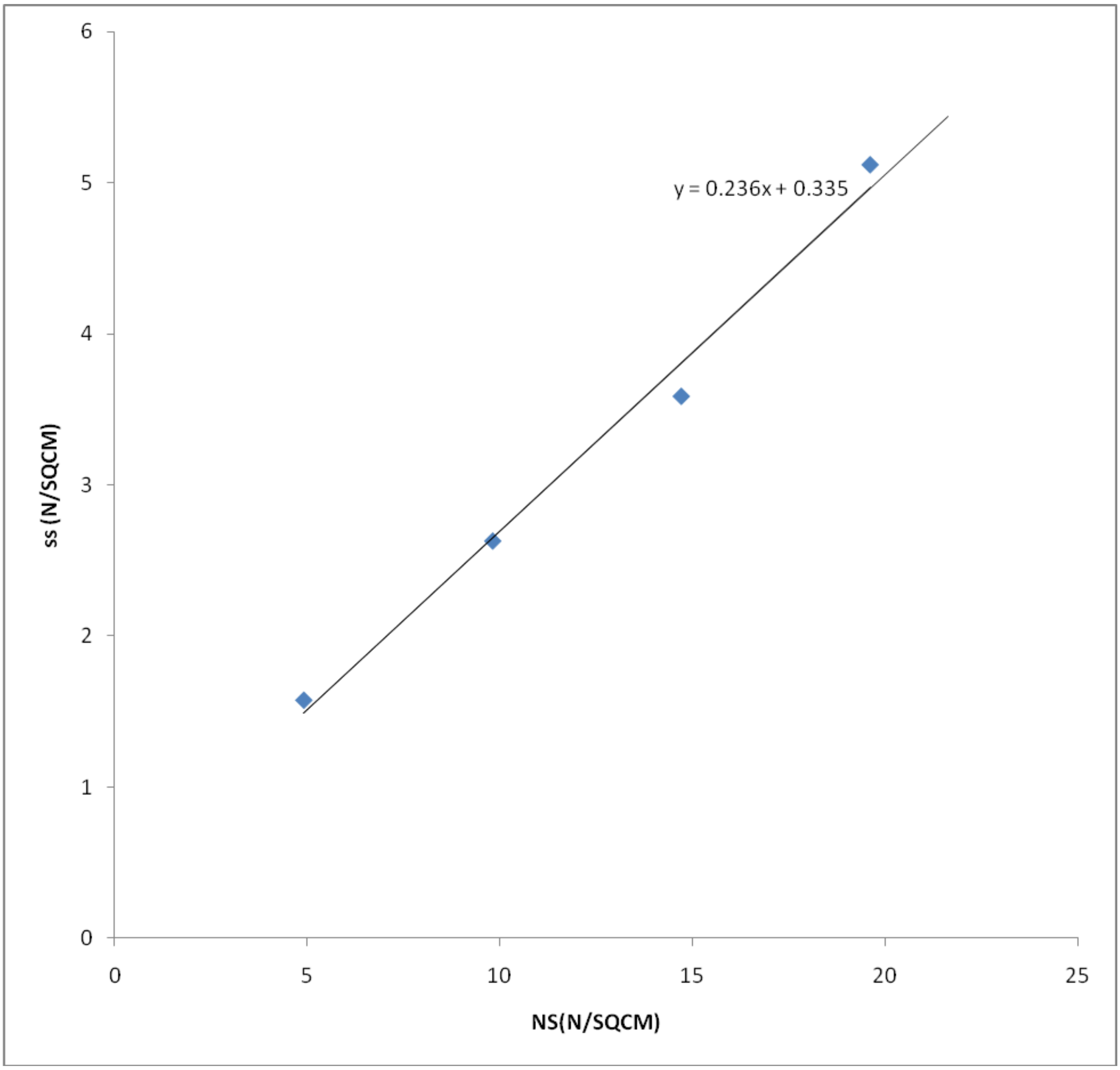

FIG. 4.28   DRY DENSITY= 1.14 gm/cc

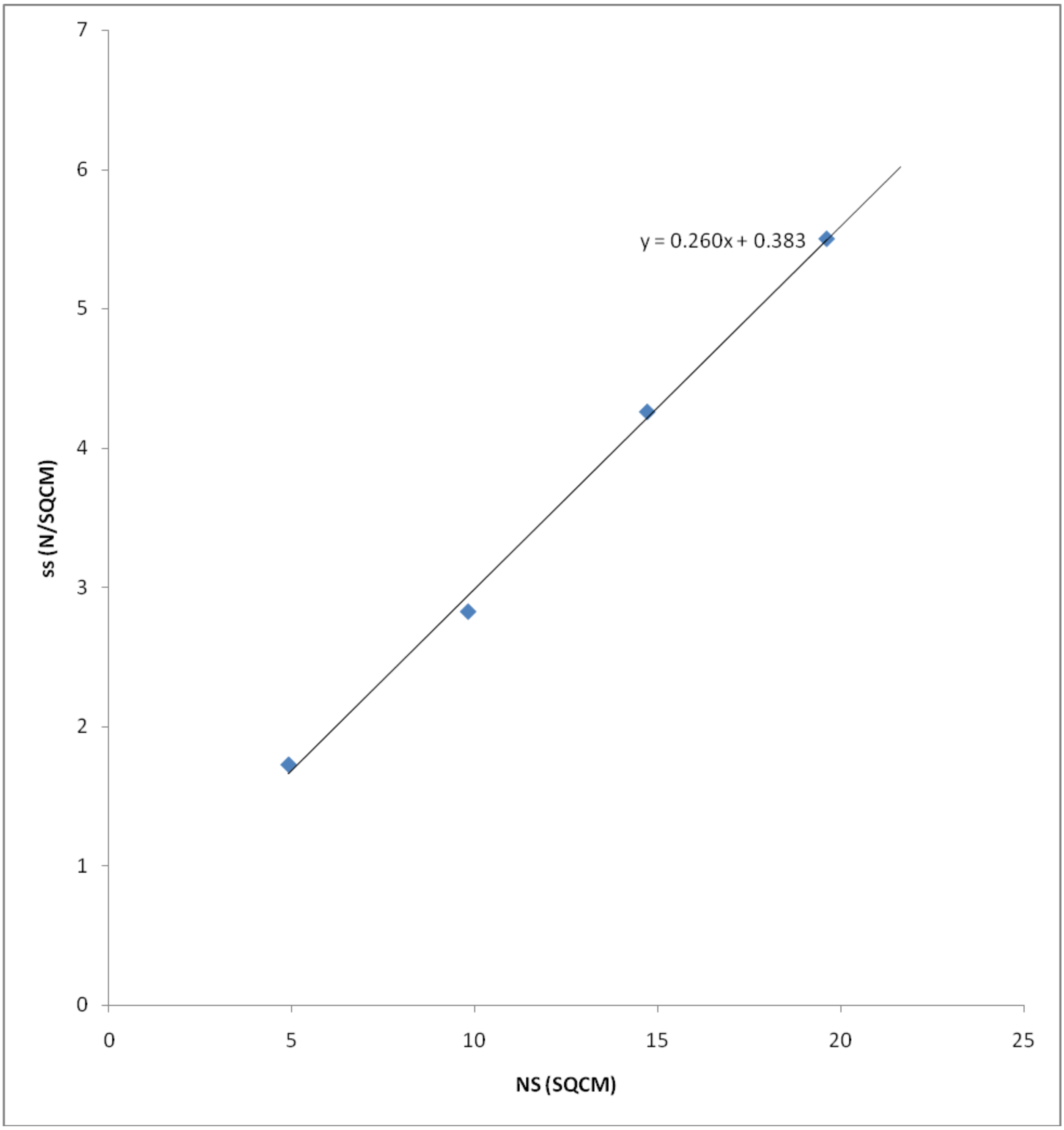

FIG. 4.29 DRY DENSITY= 1.34 gm/cc

4.2.4 DIRECT SHEAR (SATURATED SAMPLE) (MDD = 1.24 gm/cc)

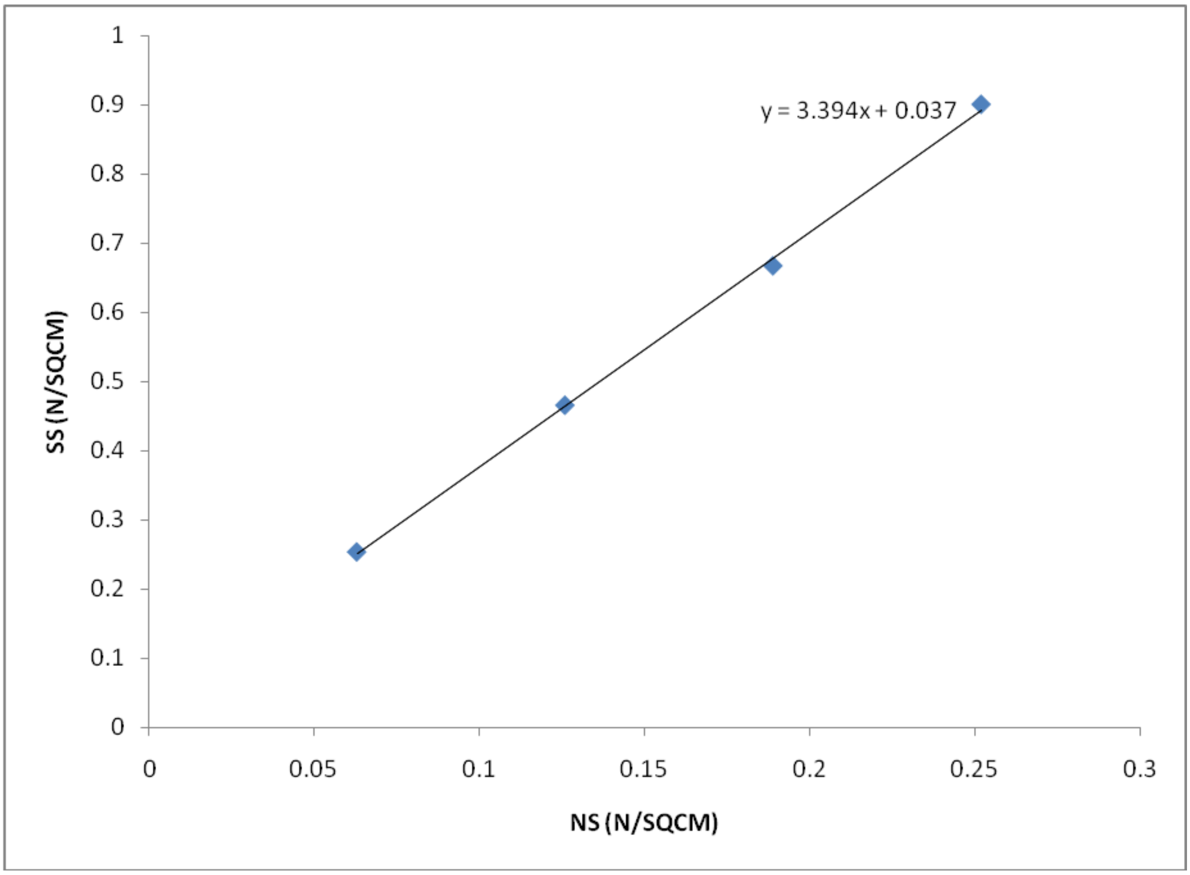

FIG. 4.30 MDD = 1.24 gm/cc

Notations:

SS = SHEAR STRESS in N/cm^2

NS= NORMAL STRESS in N/cm^2

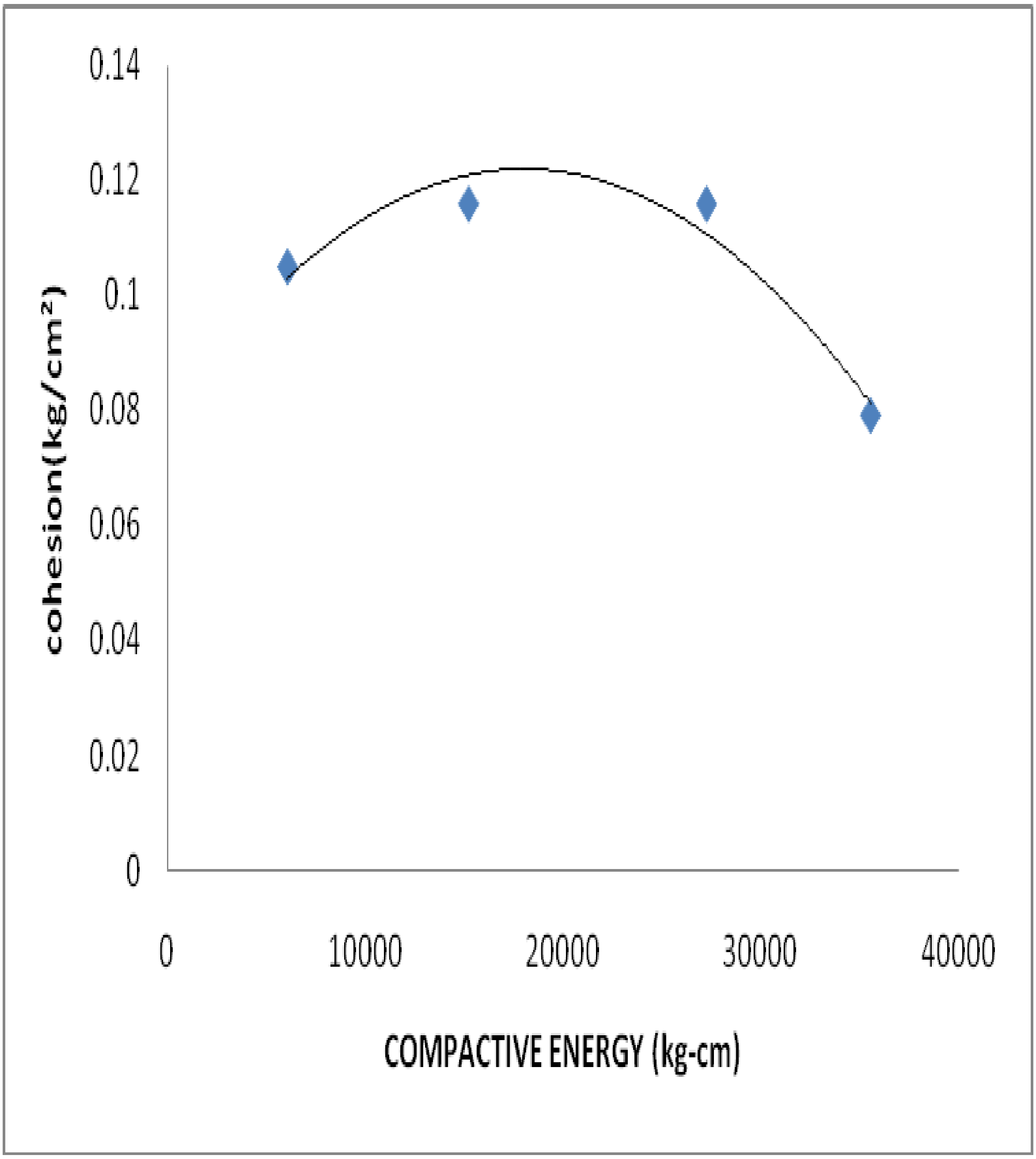
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
cohesion(kg/cm²)
0
10000
20000
30000
40000
COMPACTIVE ENERGY (kg-cm)

FIG. 4.31

4.3 Measurement of Unconfined Compressive Strength through unconfined compression test:

Unconfined compression tests were performed on unreinforced specimens according to IS: 2720 (Part 2). Cylindrical specimens with a height to diameter ratio of 2 (100 mm high × 50 mm diameter) were compressed until failure. Results are tabulated in table 3.7 to table 3.8.and graphs are plotted from fig 4.31 to fig 4.44.

4.3.1*Compressive Strength (varied with different compactive efforts):*

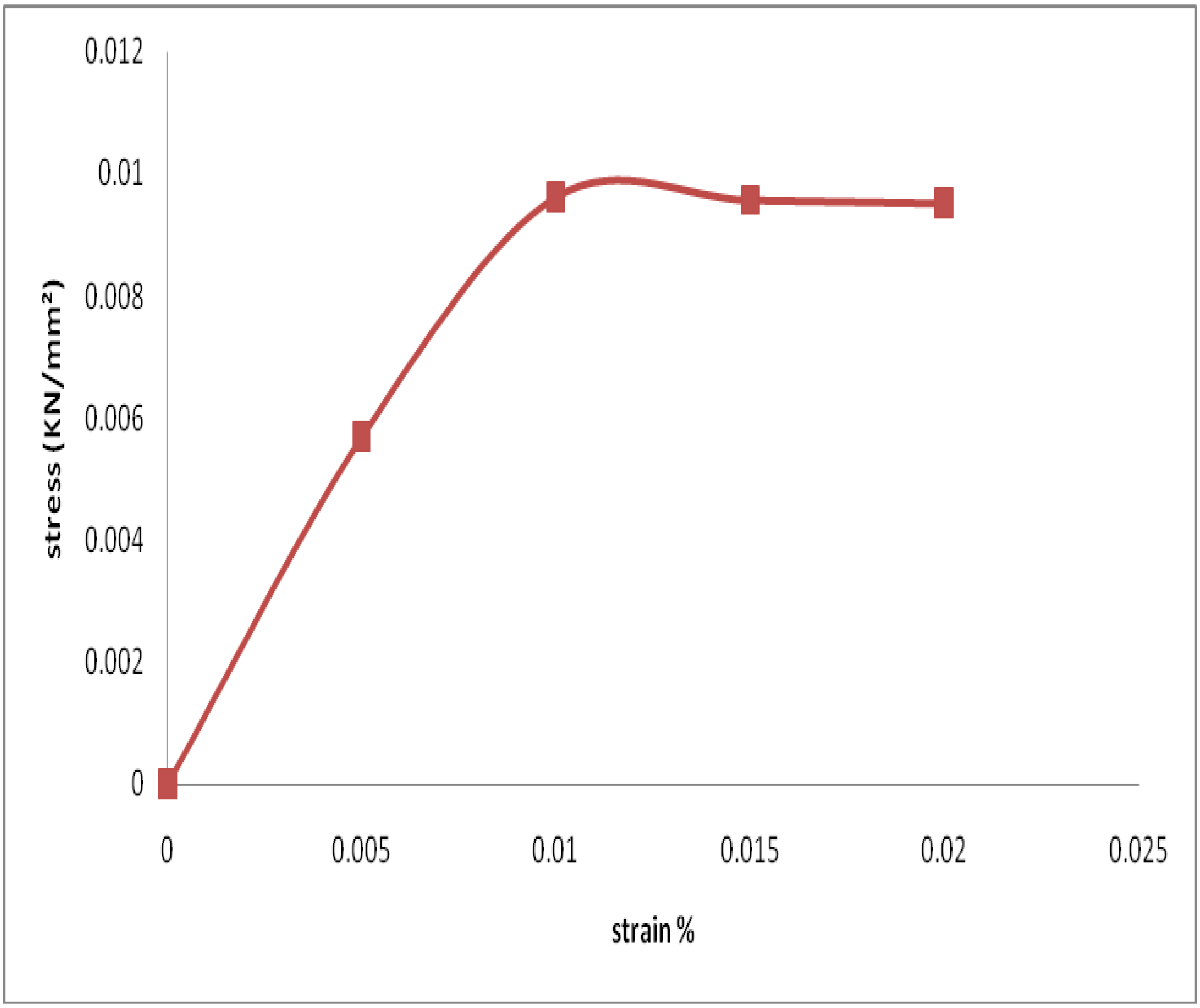

FIG. 4.32 compactive energy 35554 Kg-cm

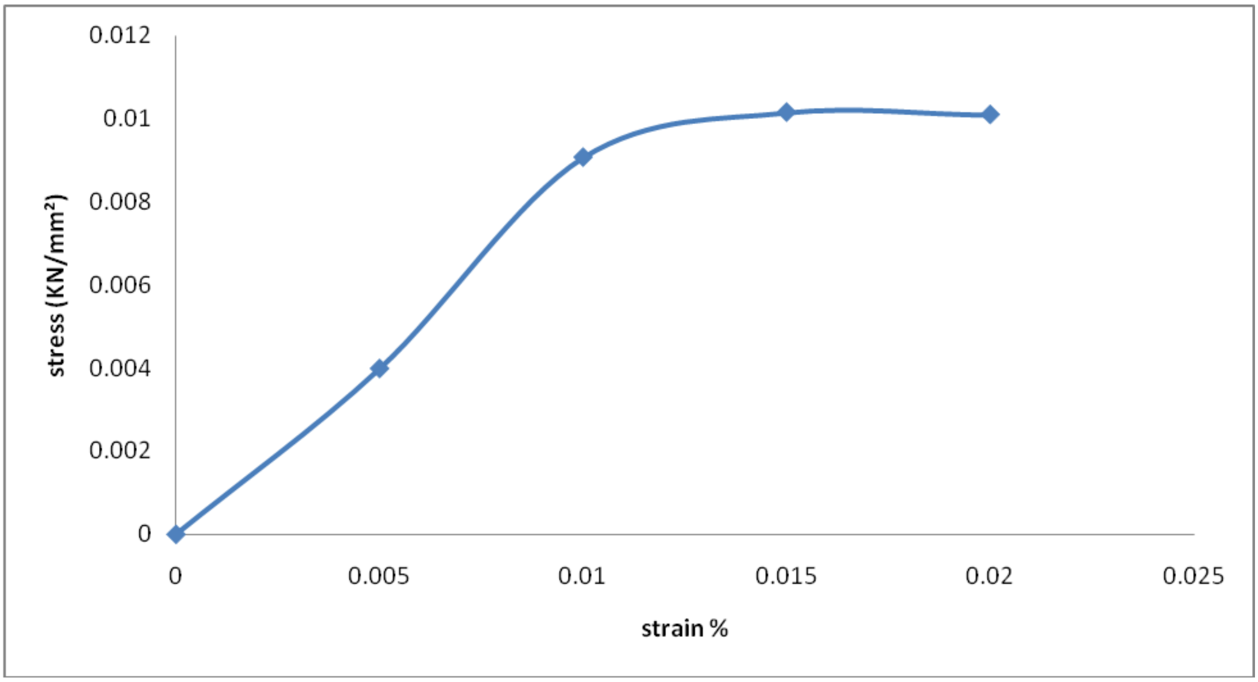

FIG. 4.33 compactive energy 28444 Kg-cm

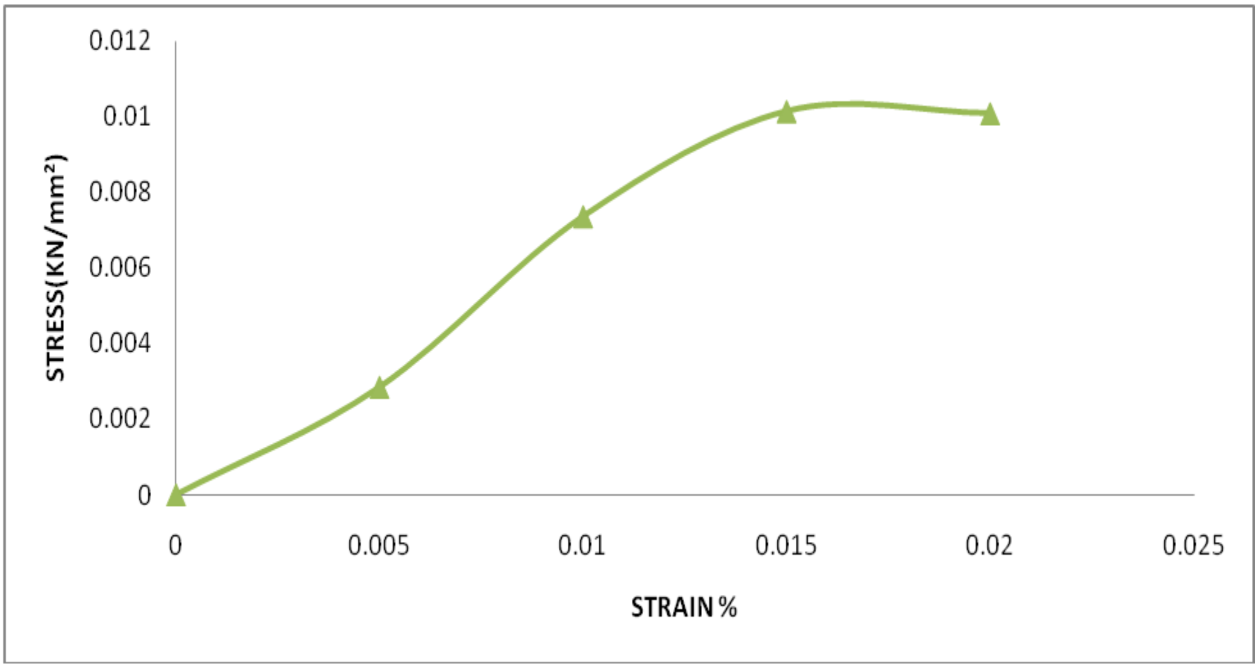

FIG. 4.34 compactive energy 27260 Kg-cm

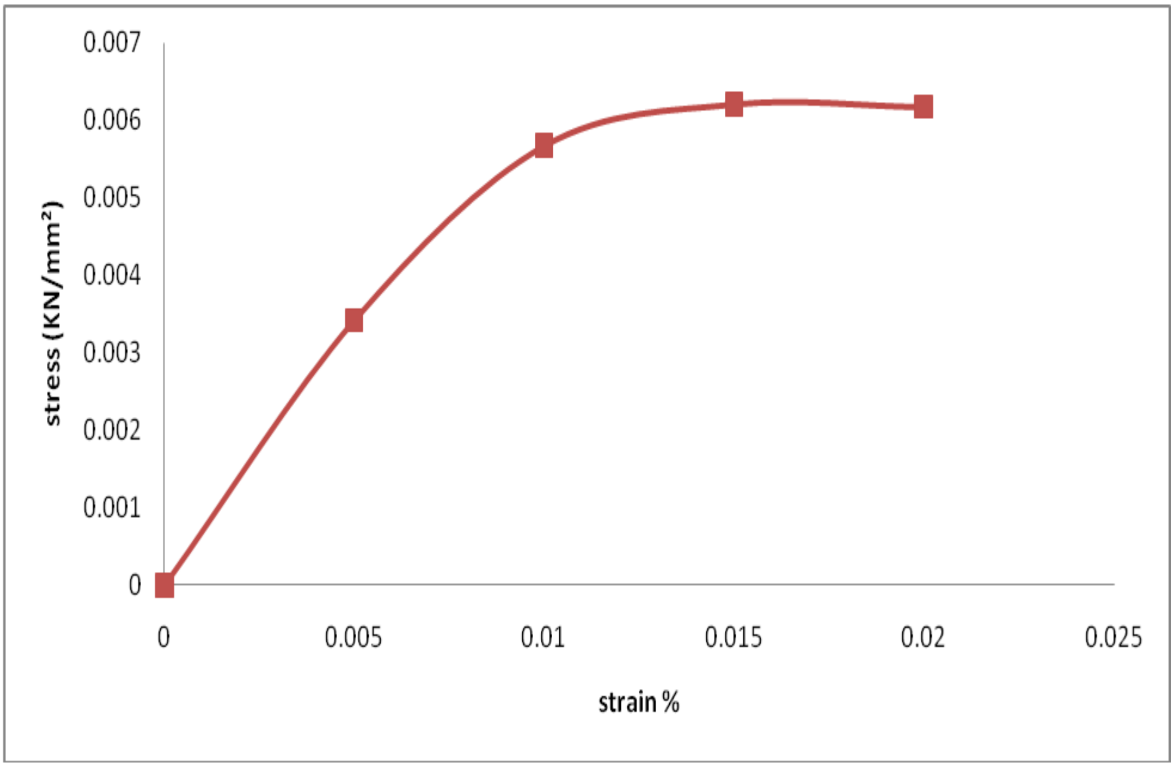

FIG. 4.35 compactive energy 15223 Kg-cm

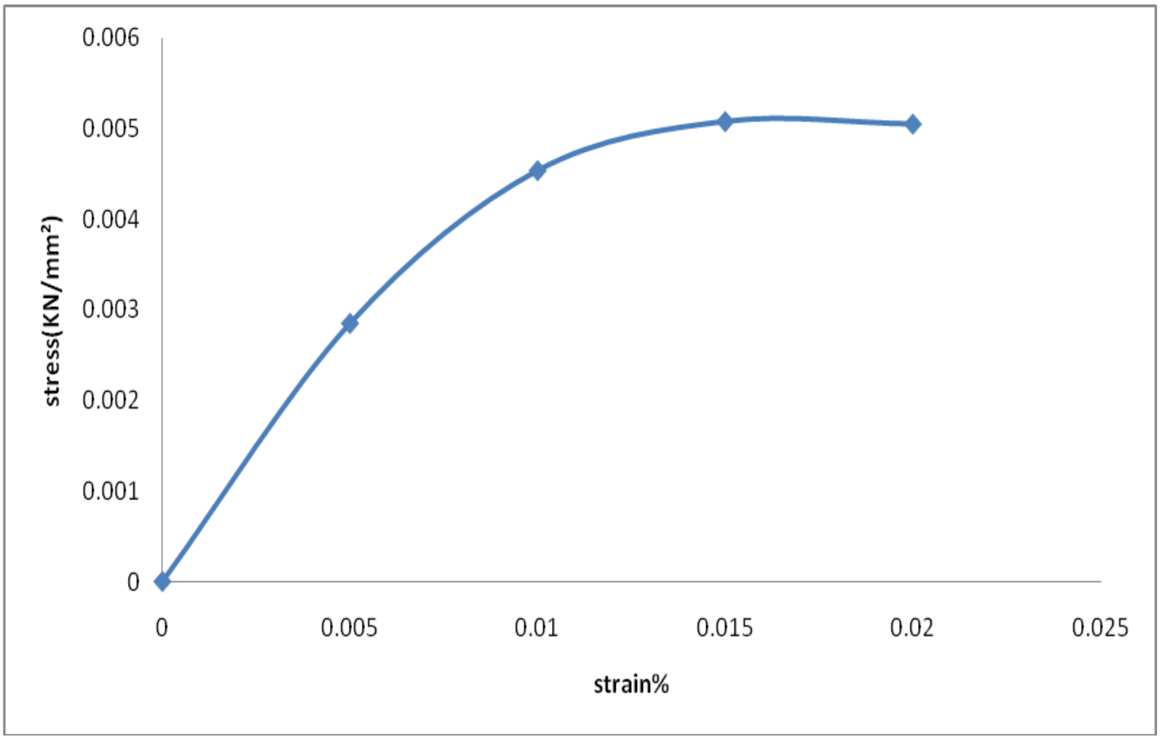

FIG. 4.36 compactive energy 6065 Kg-cm

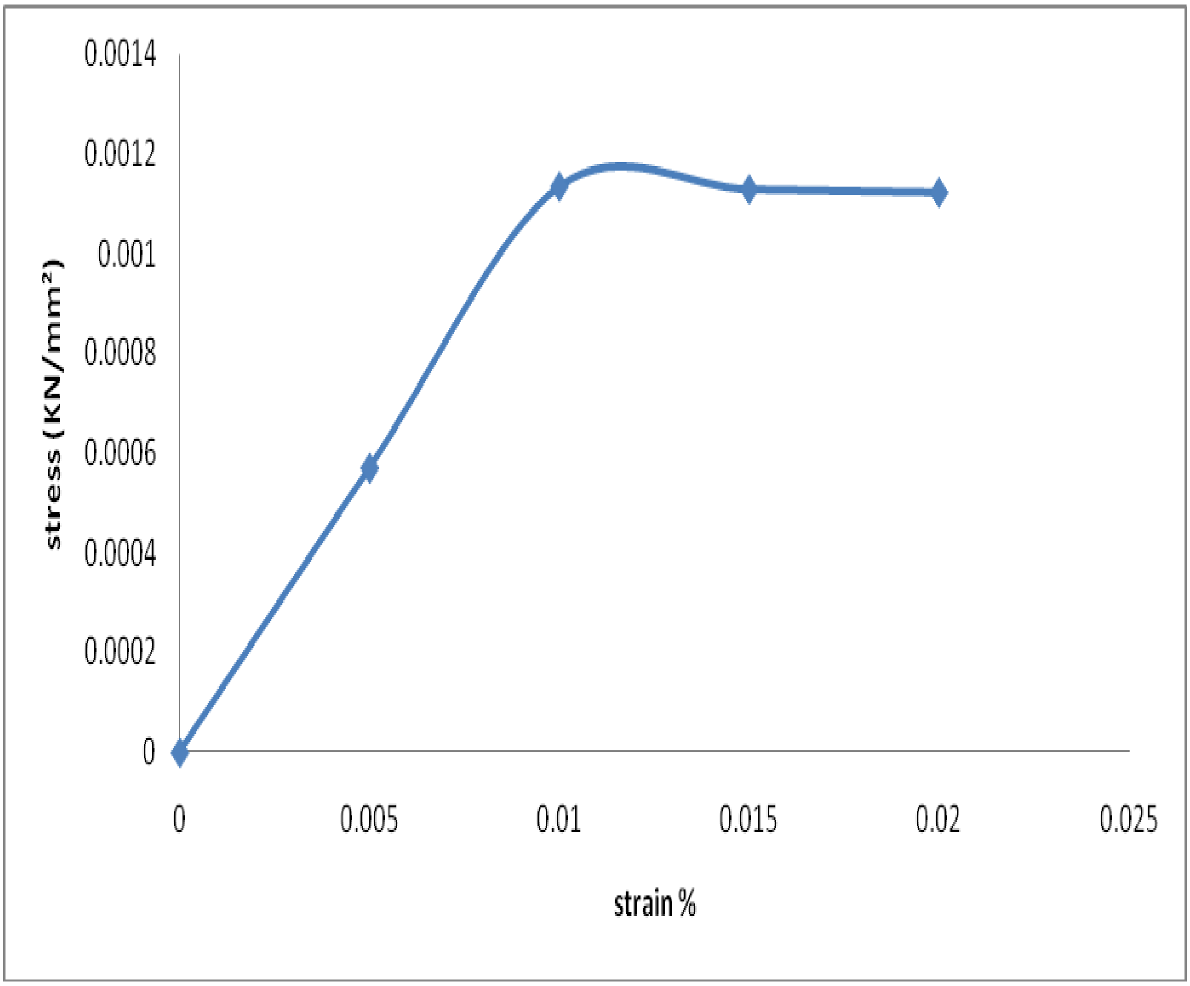

FIG. 4.37 compactive energy 3639 Kg-cm

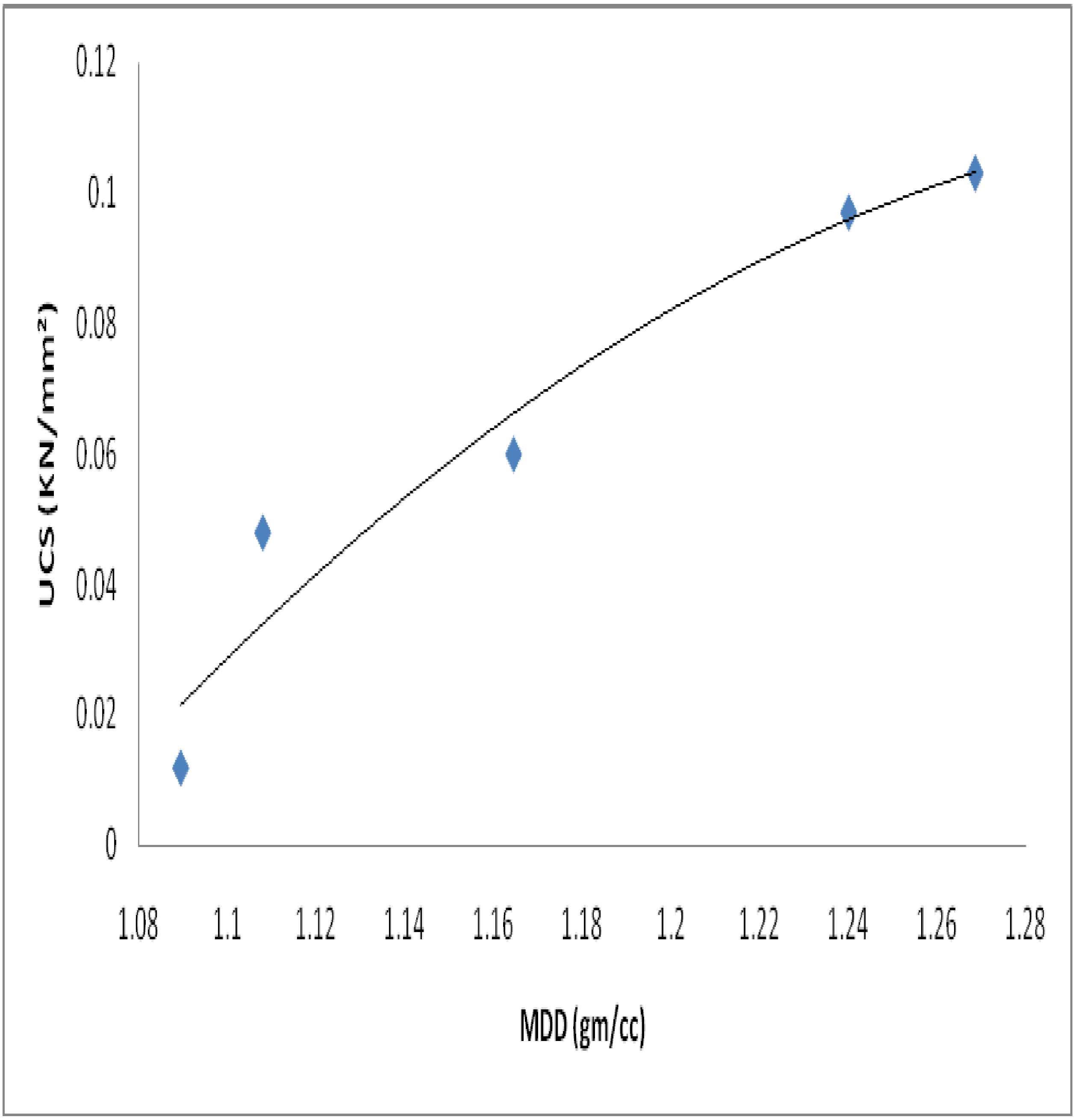
0.12
0.1
0.08
0.06
0.04
0.02
0
UCS (KN/mm²)
1.08
1.1
1.12
1.14
1.16
1.18
1.2
1.22
1.24
1.26
1.28
MDD (gm/cc)

FIG. 4.38

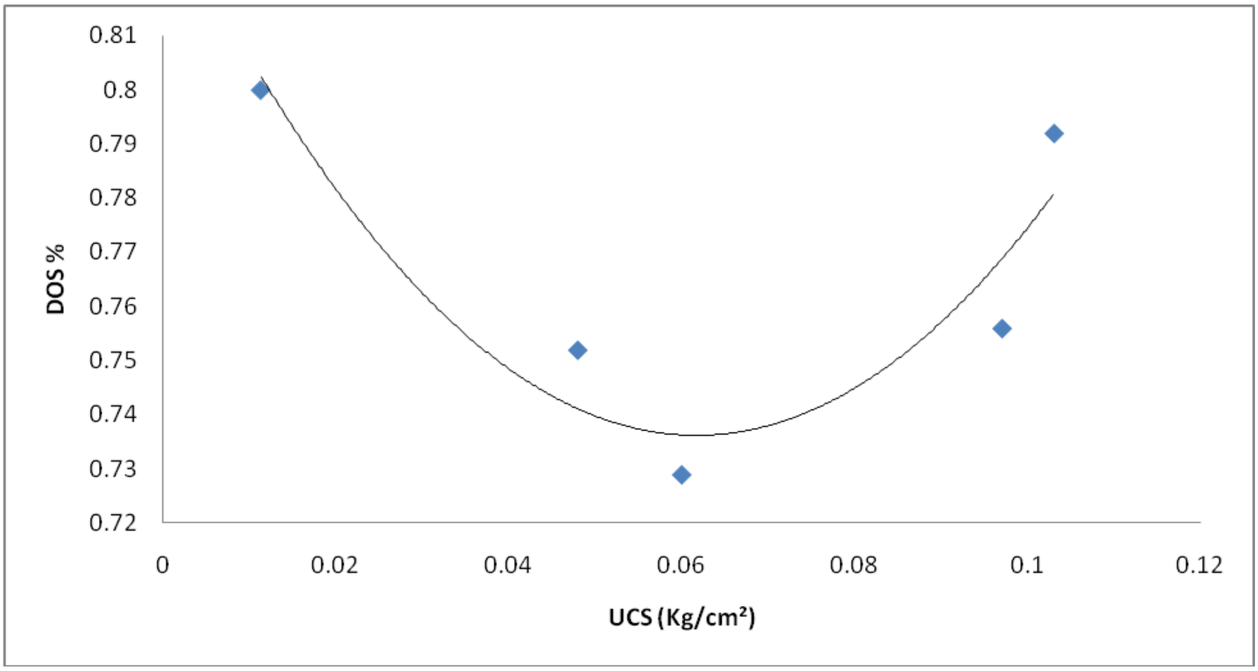

FIG. 4.39

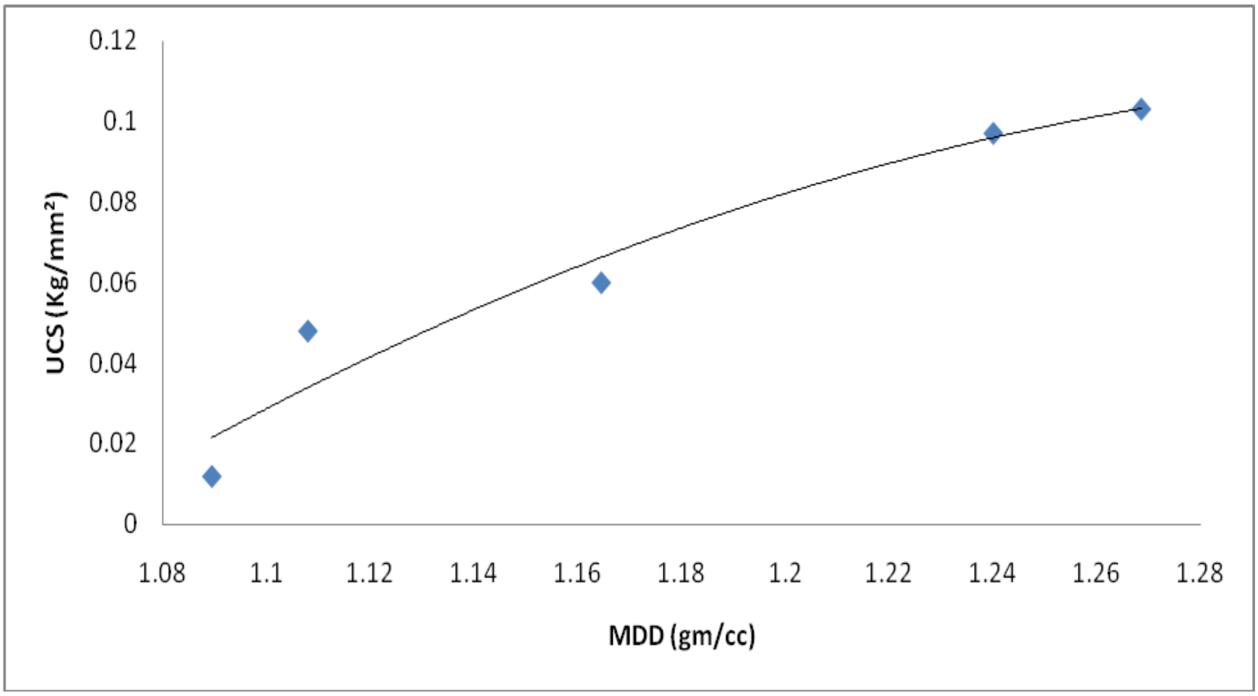

FIG. 4.40

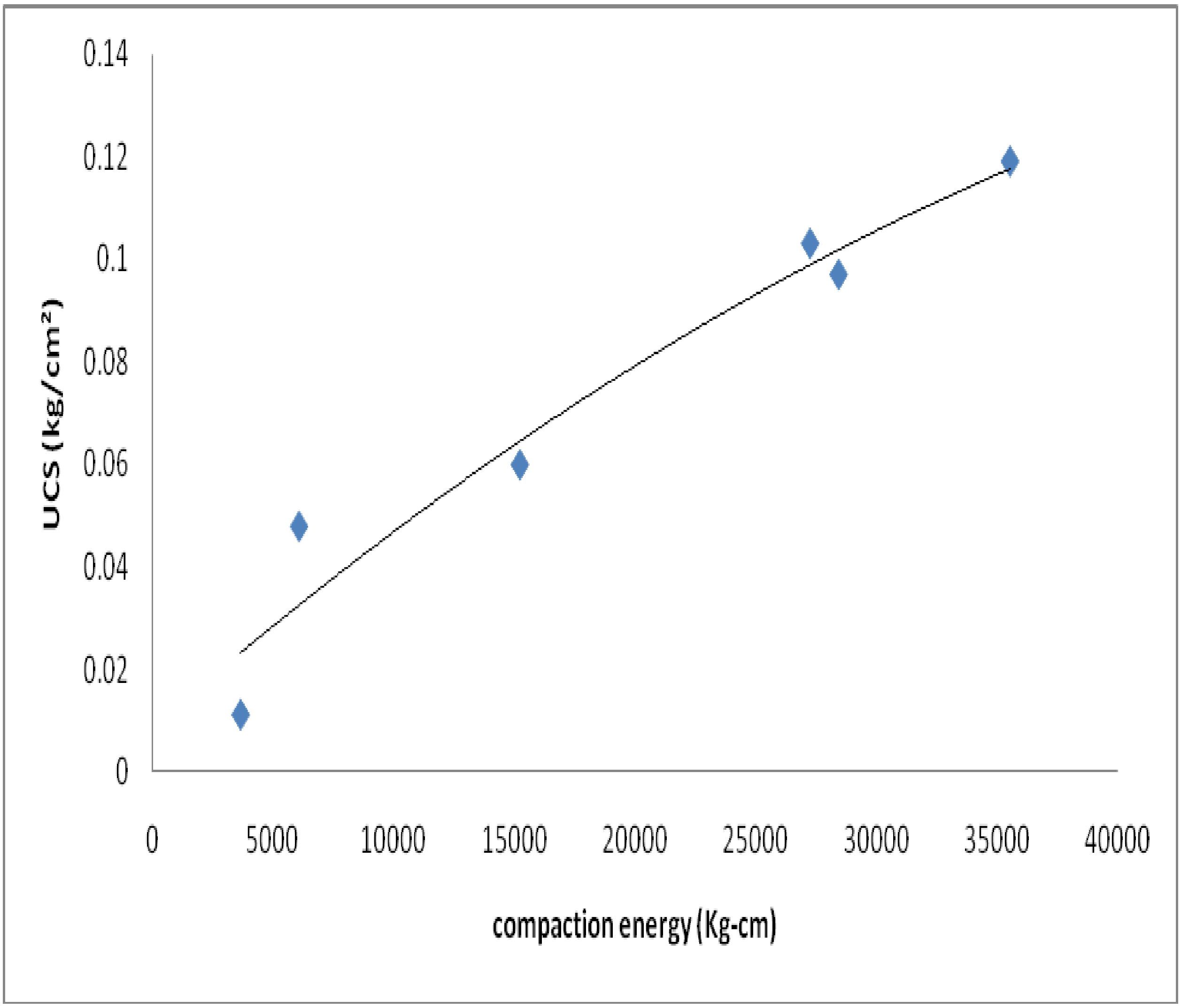
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
UCS (kg/cm²)
0
5000
10000
15000
20000
25000
30000
35000
40000
compaction energy (Kg-cm)

FIG. 4.41

4.3.2 Compressive Strength (varied with different different moisture content and fixed mdd and vice versa

(<u>MDD FIXED)</u>*Standard proctor (OMC=35.91% MDD= 1.1 gm/cc)*

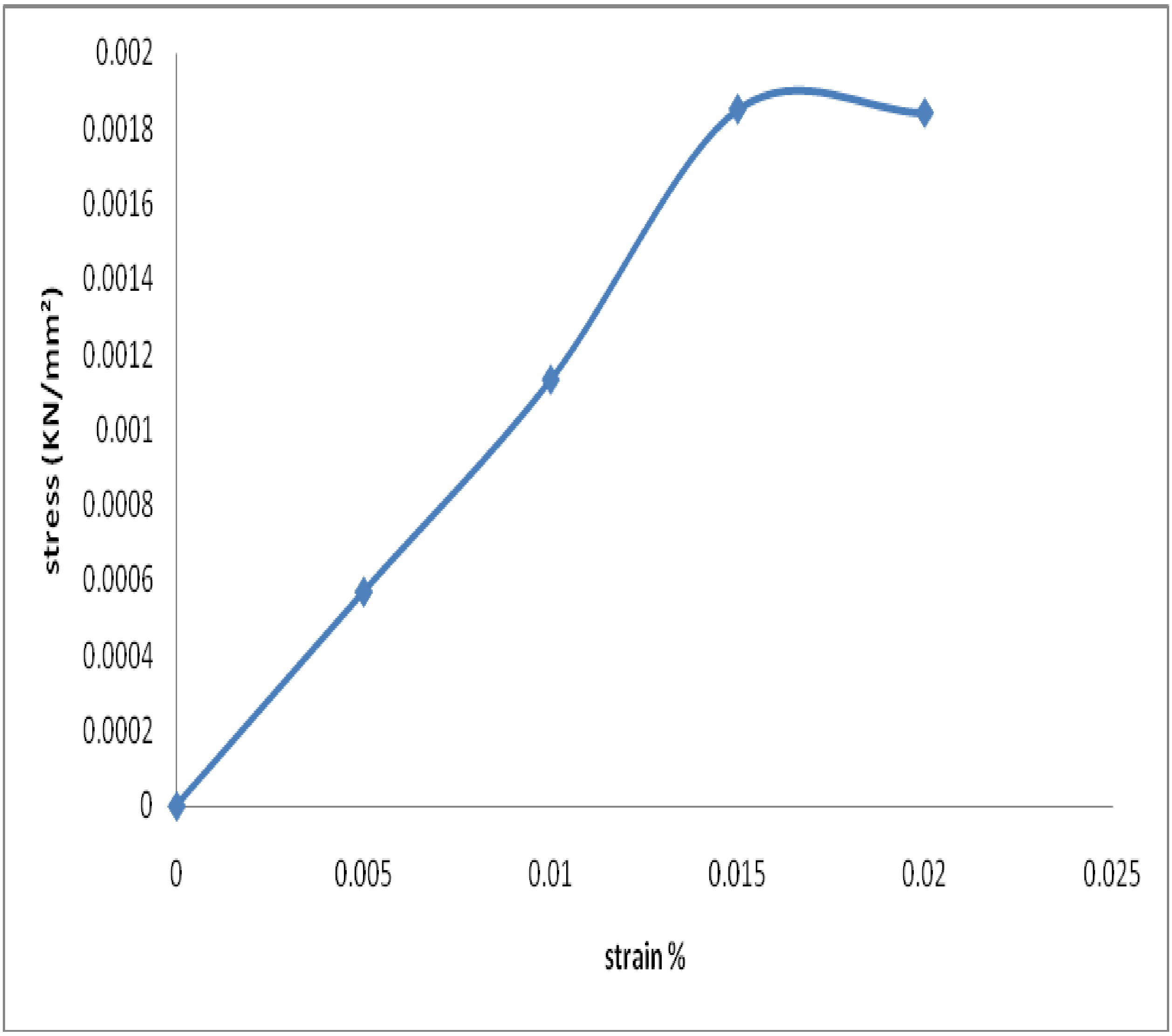

FIG. 4.42 Moisture content =45.91%

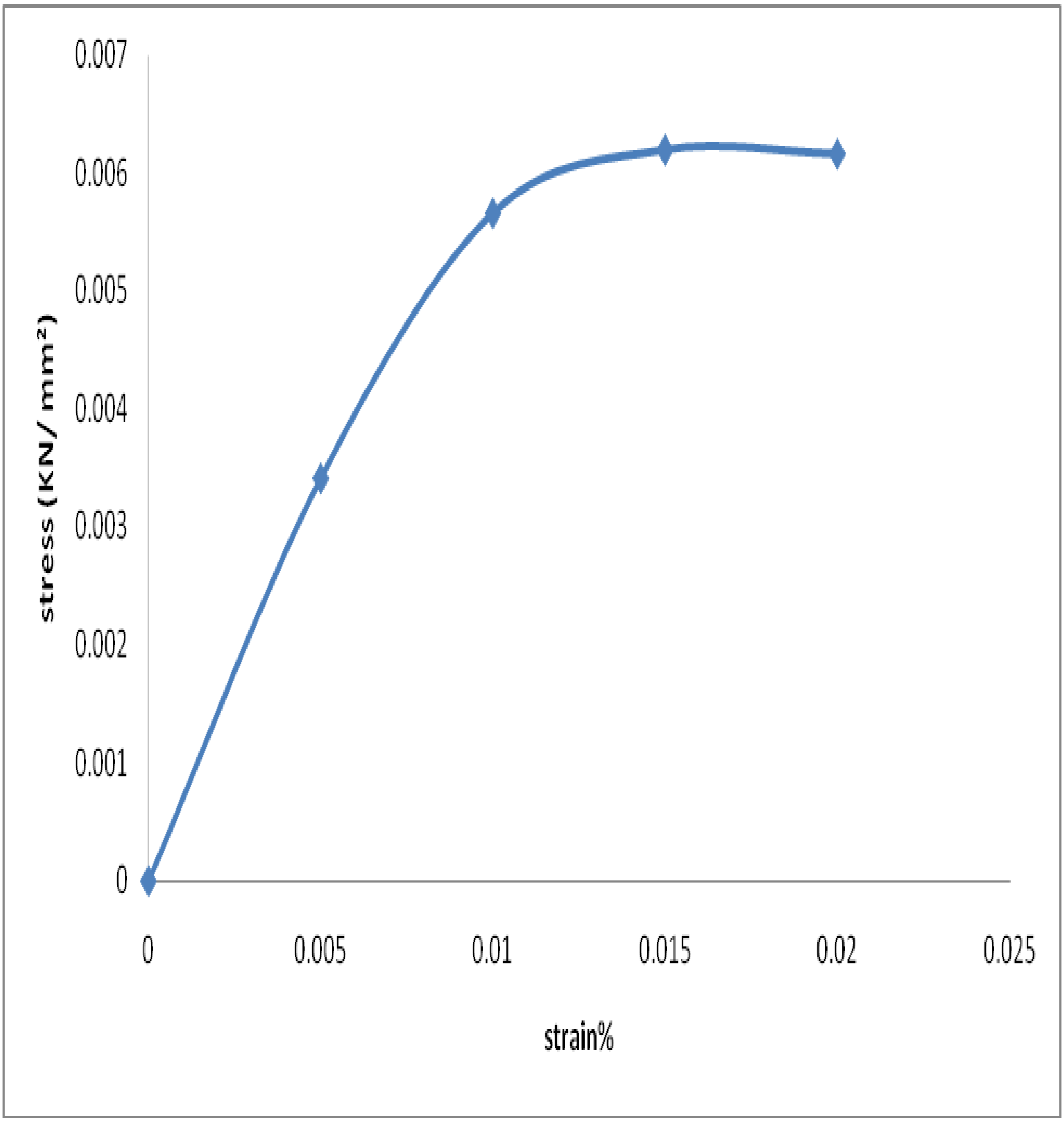

FIG. 4.43 Moisture content= 25.91%

(MDD FIXED) *modified proctor (OMC=28.30% MDD= 1.24 gm/cc)*

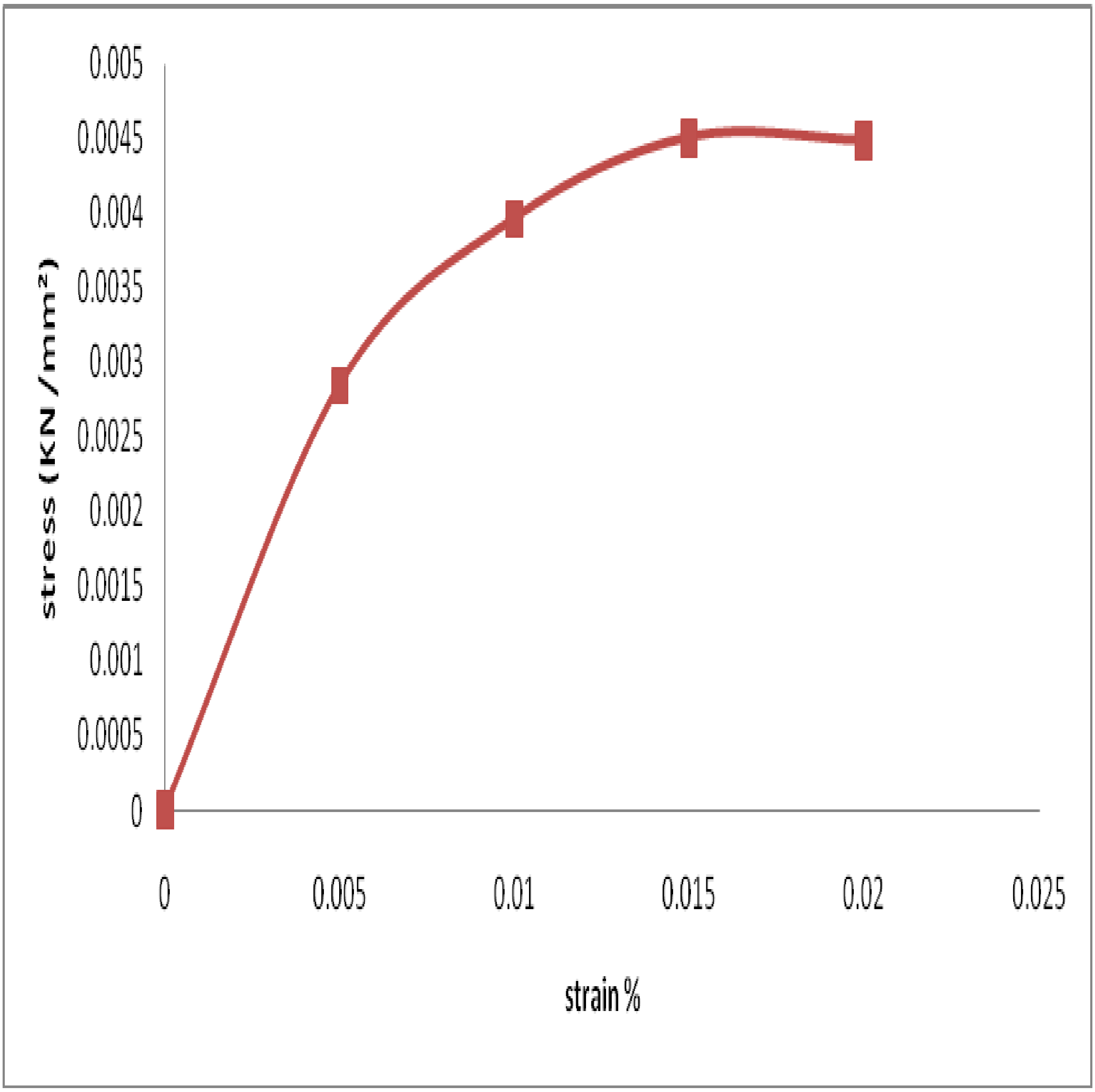

FIG. 4.44   Moisture content =38.30%

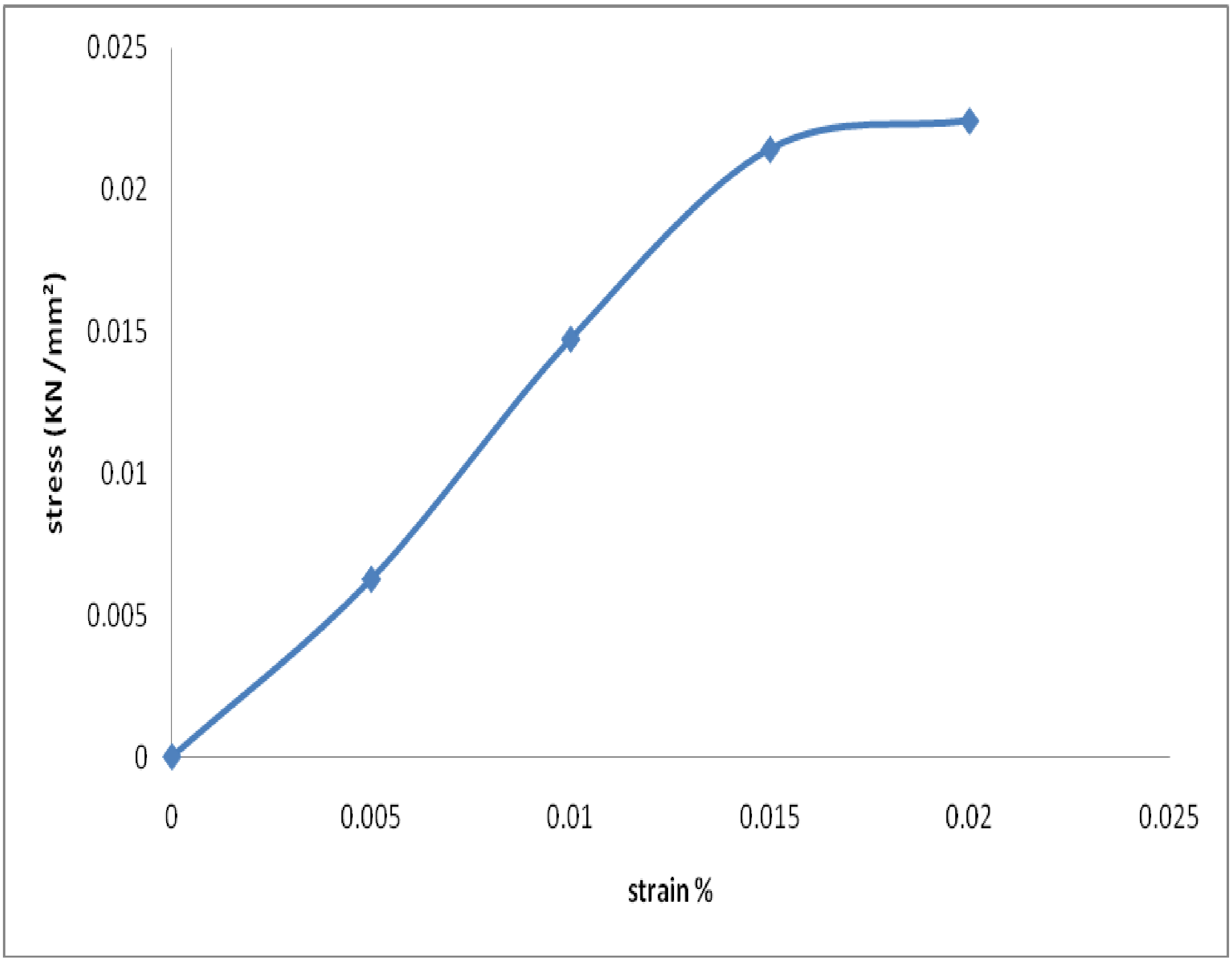

FIG. 4.45 Moisture content =18.30%

UCS = unconfined compressive strength

CE = compaction energy

CHAPTER 5

CONCLUSIONS

CONCLUSIONS

- MDD ranges from 1.09 gm/cc to 1.27 gm/cc
- OMC ranges from 28% to 39%
- Cohesion value ranges from 0.001kg/cm2 to 0.153 kg/cm2
- Compressive strength ranges from 0.0112 kg/cm2 to 0.25 kg/cm2
- As increase in amount of compaction energy results in closer packing of pond ash particles hence there is increase in dry density
- MDD increases with increase in compaction energy.a plot of MDD and different Compaction energies for pond ash shows a linear relationship. Fig 4.8
- From results it is observed that with increase in compaction energy, OMC decreases. This may be due to the phenomenon that with increase in moisture content the friction between the particles of the pond ash decreases, thereby enhancing the tendency of the particles to come closer with increase in compaction energy as a result of which air voids decrease and thus degree of saturation increases.
- It is shown in results,With increase in compaction energy from 3639 to 35554 kg-cm, MDD of pond ash increases, but at the same time OMC decreases.

- shear strength tests on freshly compacted pond ash specimens at various water contents and different dry densities show that most of the shear strength is due to internal friction.

- Angle of friction doesn’t change much when we applied different compactive efforts

- Cohesion value decreases as we applied more compactive effort.

- Unconfined compressive strength increases as we applied more compactive effort

- Relationship between unconfined compressive strength and MDD is almost linear.

- Relationship between unconfined compressive strength and compaction energy is linear.

CHAPTER 6

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5) A. Sridharan, N. S. Pandian And C. Rajasekhar, Geotechnical Characterization Of Pond Ash, Ash Ponds And Ash Disposal Systems (V. S. Raju Et Al., Eds), Narosa Publishing House, New Delhi, Pp. 97–110 (1996).

6) A. Sridharan, N. S. Pandian And S. Srinivas, Shear Strength Characteristics Of Pond Ash For Use As Structural Fills, Fly Ash Disposal And Deposition: Beyond 2000 Ad (V. Dayal Et Al., Eds), Narosa Publishing House, New Delhi (1999).

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9) High volume fly ash concrete technology –fly ash status summary report in india.

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